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SURGERY

ITS PRINCIPLES AND PRACTICE

BY VARIOUS AUTHORS

EDITED BY

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EMERITUS PROFESSOR OF THE PRINCIPLES OF SURGERY AND OF CLINICAL SURGERY, JEFFERSON MEDICAL COLLEGE, PHILADELPHIA

AND

JOHN CHALMERS DaCOSTA, M.D.

SAMUEL D. GROSS PROFESSOR OF SURGERY, JEFFERSON MEDICAL COLLEGE, PHILADELPHIA

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VOLUME IV

With 582 Illustrations, 22 of them in Colors

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CONTRIBUTORS TO VOLUME IV

ROBERT ABBE, A.B., M.D.

Surgeon to St. Luke's Hospital, New York City

ARTHUR DEAN BEVAN, M.D.

Professor and Head of the Department of Surgery, Rush Medical College in Affiliation with the University of Chicago; Surgeon to the Presbyterian Hospital

ARTHUR TRACY CABOT, A.M., M.D.

Late Consulting Surgeon to the Massachusetts General Hospital, to the Children's Hospital, and to the New England Hospital for Women and Children

WILLIAM B. COLEY, M.D.

Associate in Surgery, College of Physicians and Surgeons, Medical Department of Columbia University; Attending Surgeon to the General Memorial Hospital; Associate Surgeon to the Hospital for Ruptured and Crippled

EDWARD BRADFORD DENCH, Ph.B., M.D.

Professor of Otology, University and Bellevue Hospital Medical College; Attending Aural Surgeon to the New York Eye and Ear Infirmary; Consulting Otologist to St. Luke's Hospital and to the New York Orthopaedic Dispensary and Hospital

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Assistant Professor of Surgery, Northwestern University Medical School; Professor of Surgery, Post-Graduate Medical School; Attending Surgeon, Post-Graduate, Charity and Wesley Hospitals, Chicago

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JOSEPH RANSOHOFF, M.D., F.R.C.S. Eng.

Professor of Surgery in the Ohio-Miami Medical College of the University of Cincinnati; Surgeon to the Cincinnati, Good Samaritan and Jewish Hospitals

PRESLEY MARION RIXEY, M.D.

Surgeon General, U. S. Navy, Retired

WILLIAM L. RODMAN, M.D., LL.D.

Professor of Principles of Surgery and Clinical Surgery, Medico-Chirurgical College; Surgeon to the Medico-Chirurgical Hospital, Philadelphia General Hospital, Jewish Hospital, and Presbyterian Hospital, Philadelphia

WELLER VAN HOOK, A.B., M.D.

Consulting Surgeon, Michael Reese Hospital, Chicago

HUGH HAMPTON YOUNG, M.A., M.D.

Associate Professor of Genito-Urinary Surgery, Johns Hopkins University; Associate in Surgery, Johns Hopkins Hospital

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SURGERY

KEEN

SURGERY

ITS PRINCIPLES AND PRACTICE.

CHAPTER LIII.

HERNIA.

By William B. Coley, M.D.,

NEW YORK.

General Considerations.—The term "hernia" is probably derived from the Greek word ἔρνος, meaning "an offshoot," and, strictly speaking, may be applied to any protrusion or projection from the surrounding surface, *e. g.*, hernia cerebri. When used alone, the term hernia has come to be synonymous with rupture, and is applied to a protrusion of some one or more of the abdominal viscera, through a normal or an abnormal opening. While rupture is the term most commonly used by the laity in describing this condition, it is misleading, since it rests upon a false conception of the etiology. The term originated at a time when it was generally believed that traumatism, or a tearing of the muscular structures by some direct or indirect violence, was a frequent and important cause. The great increase in our knowledge, as a result of the large number of operations for the radical cure of hernia that have been performed during the last two decades, has proved that in the vast majority of cases "hernia is a disease rather than an accident." In other words, it is due to a congenital defect, *e. g.*, an open funicular process of peritoneum, or an abnormal size of some normal opening in the abdominal wall. This congenital defect, then, is the main cause of a hernia, while the immediate or exciting cause plays but a minor rôle.

A hernia is made up of three parts: (1) the sac; (2) the covering of the sac; (3) the contents of the sac. All hernias have been generally divided into two groups, *i. e.*, congenital and acquired. These terms, however, have given rise to a great deal of confusion. Even now there is no well-settled rule as to their proper interpretation. Some writers class as congenital all hernial sacs which are preformed, calling acquired all sacs that have developed after birth. This would be an excellent rule, were it possible to apply it practically. Inasmuch as the only way of definitely telling that a sac is preformed or of pre-natal origin is by the fact that it communicates with the tunica vaginalis testis, it has been a

rule with most writers to class as congenital hernias only such as showed this connection. This test, however, rules out not only a very large number of sacs in the male, in which by reason of the appearance of a hernia in earliest infancy the presence of a preformed sac is practically proved, but it also rules out all cases of inguinal hernia in the female. To thus restrict the term "congenital" to a comparatively small proportion of cases in the male is, I believe, most misleading. It is probable that in the vast majority of inguinal hernias in the male, and practically all in the female, the sac is preformed, *i. e.*, there is an open funicular process of peritoneum existing at birth, even though the hernia may not develop until adult life. The principal exception to this broad generalization would be the direct hernias. This variety of hernia more accurate knowledge has shown to be far less frequent than has hitherto been supposed. My own operative statistics show 39 cases of direct hernia in a total of over 1950 operations. Of these, only two occurred in the female.

It may sometimes be possible to distinguish a congenital or preformed sac from an actually acquired hernial sac, *i. e.*, one formed after birth,

FIG. 1.—VARIETIES OF PREFORMED SACS (R. Hamilton Russell).

by the intimacy of its relationship to the cord and its vessels in the male, and to the round ligament in the female. The acquired sac, a type of which we have in the direct hernia, is simply a bulging forward of the parietal peritoneum into some opening or weak place in the abdominal wall. This sac has no intimate connection with the cord or the round ligament.

In a preformed or congenital sac, on the other hand, we find, especially in children (and this is equally true whether the sac connects with the tunica vaginalis or not), the sac in the most intimate relationship with the cord and cord vessels, the latter lying in closest contact with the thin membrane of the sac, and both surrounded by the infundibuliform fascia. In many cases the sac extends down to the tunica vaginalis testis without communicating with it. But such communication is of no importance in estimating its claim to being classed as congenital. Some writers have recently gone so far as to class all inguinal and femoral hernias as congenital, with the possible exception of some cases of direct inguinal hernia. This position has been taken and most ably defended by R. Ham-

ilton Russell, of Melbourne.[1] Russell has seen a direct hernial sac in the cadaver of a man who had no hernia during life. A number of similar cases of congenital pouches of peritoneum have been found in the femoral region, in which cases there was no history of hernia during life. Furthermore, Russell cites much evidence based on embryologic research, which seems to prove that such pouches of peritoneum actually do occur, and not infrequently in the femoral canal. Whether these be regarded as a normal event of "developmental accident" is of no particular moment. If these facts be true, we have a better explanation of the origin of femoral hernia than any that has hitherto been offered.

Anatomic Varieties of Hernia.—Among the most common varieties in their order of frequency are (1) inguinal, (2) umbilical, (3) femoral, (4) ventral. The rarer forms are: obturator, ischiatic, pelvic, lumbar, diaphragmatic, and the various forms of retroperitoneal hernia, *e. g.*, duodenal, retrocecal, hernia of the foramen of Winslow.

Clinical Varieties of Hernia.—Reducible, irreducible, inflamed, strangulated.

Reducible Hernia.—This is by far the most common of all varieties of hernia. Here the contents of the hernial sac, no matter of what form the hernia may be, are returned into the abdominal cavity either spontaneously, on the patient's lying down, or by manipulation on the part of the physician. In some cases in which the hernial sac is large and the neck comparatively small, a good deal of effort on the part of the physician may be required to accomplish reduction. In the early stage of development practically all hernias are reducible.

The Sac.—Whatever the variety of hernia, there is one feature common to all, and that is the sac. This sac is formed by a layer of peritoneum and covers in whole or in part the contents of the hernia. In the congenital type, the hernial sac is a preformed pouch or diverticulum of peritoneum, first empty, until by some unusual effort or accident causing an increase in the abdominal pressure, some of the abdominal viscera are forced into this pouch. In the acquired variety, the best examples of which are seen in the direct inguinal, epigastric, and ventral hernias, the parietal peritoneum is forced by intra-abdominal pressure through some congenital defect in the abdominal wall. In epigastric hernia this is often a transverse slit in the fascia, through which the omentum is forced like a thin wedge, gradually dilating the opening until a well-marked hernia is formed. Under certain conditions a hernial sac may be incomplete, *e. g.*, in sliding hernia of the cecum or sigmoid and, occasionally, in hernia of the bladder. In these cases the sac anteriorly is like an ordinary sac, while posteriorly it is continuous with the anterior surface of the cecum or sigmoid. Such cases offer considerable difficulty in operations for radical cure. Figs. 1, 2, and 3 illustrate types of sac observed by the author in operations for radical cure of hernia.

In the rarer forms of internal hernia, *e. g.*, diaphragmatic, in most cases no sac is present. In ventral hernia following laparotomy there is a gradual thinning out of the cicatrix, forming a large pouch, in which there may be no sac or a partial one. In still rarer cases there may be

a rupture of the peritoneum and the contents of the sac (omentum or bowel) may pass downward into the canal, covered only by muscle and

FIG. 2.—HERNIA WITH HYDROCELE.

FIG. 3.—SLIDING HERNIA OF THE CECUM.

fascia. Some authors deny the existence of such a condition, but the writer has operated upon one such case, which proves that it may occur (Fig. 4).

FIG. 4.—HERNIA WITHOUT A SAC (OCCURRING IN MAN TWENTY-FOUR YEARS OF AGE; NO HISTORY OF TRAUMA OR OF UNUSUAL STRAIN).

Size and Shape of the Sac.—This may vary from a fusiform protrusion hardly larger than a slate-pencil, to an enormous pouch, containing nearly all of the contents of the abdomen. Every organ except the spleen and pancreas has been found in the sac, and in some cases the sac reaches as far down as the knees. Some writers, *e. g.*, Bayer, hold that the shape of the sac in congenital hernia differs from that in acquired hernia, being pear-shaped with a narrow neck in the congenital variety, while in the acquired type it has a broader neck and narrower base.

I do not think this distinction can readily be made, nor is it of much practical value. The sac, being a part of the peritoneum, has the same anatomic characteristics. It is a smooth, elastic membrane, exceedingly thin and transparent in children. It may be easily irritated by means of a truss, giving rise to an inflammatory exudate, which may cause adhesions between the sac and the contents of the sac.

Relation of the Sac to Other Structures.—In oblique inguinal hernia

the sac bears a constant relation, both to the cord and to the overlying structures. It always lies in a position anterior to the cord and to the cord vessels and is surrounded, in common with the latter, with the thin layer of infundibuliform fascia. Next in order, from within outward, comes the cremasteric fascia and muscle; then the superficial fascia, and, finally, the skin. In inguinal hernia in the female we find the sac bearing the same relation to the round ligament as it does to the cord in the male, *i. e.*, it lies directly over or in front of the round ligament and is very closely attached to it. In direct inguinal hernia in the male the sac emerges through the abdominal wall, below the epigastric artery, through the external inguinal ring. Strictly speaking, it is a ventral hernia, and in most cases, I believe, the sac is acquired. It pushes the cord directly in front of it or to one side, and has no such intimate relation to the cord as is found in the oblique variety. In direct hernia the shape of the sac differs considerably from that in the oblique variety, being almost spherical; it practically always enlarges directly outward and rarely, if ever, enters the scrotum.

The Neck of the Sac.—That portion of the sac which is the narrowest, usually situated within the hernial orifice, is known as the neck of the sac. In a few cases it is a well-defined circular ring, but in most cases no such definite outline can be made out. Much importance has been attached to the neck of the sac for the reason that in many cases it was supposed to be the chief cause of strangulation. In most of the text-books and monographs upon strangulated hernia the cause of the strangulation has been attributed to the neck of the sac; the same has been true in reports of operations in children as well as adults. Yet in nearly all cases the strangulation is easily reduced, if the tense fibers of the external ring are first cut, thus proving that the neck of the sac could not have been the cause. In seventeen cases of strangulated hernia in children operated upon at the Hospital for Ruptured and Crippled, the external ring was the cause of strangulation in all but one. In this case the neck of the sac was a firm ring of cicatricial tissue. In the great majority of cases the neck of the sac will be found to be simply a thin, elastic membrane, which, though somewhat narrower than other portions of the sac, is easily distensible and quite incapable of producing the strangulation for which it is so frequently held responsible.

Changes in the Sac.—While originally a very thin membrane, the sac may undergo important changes, especially in hernia of long standing or in cases in which an ill-fitting truss has been worn for a long time. In such cases the sac may become greatly thickened and of leathery consistence, while in some rare cases it may undergo calcification.

Different Types of Sacs.—The shape of the sac varies greatly, as is shown by the accompanying cuts (Figs. 5 to 10), taken from cases operated upon by the author. In scrotal hernia the most common form of sac is the pear-shaped, with the fundus below and the neck above the internal ring. There may be a constriction half-way between neck and fundus, giving rise to the hour-glass shaped sac (Fig. 7). Many sacs are

irregularly sacculated, and in some cases there may be a perfectly formed double sac (Figs. 9 and 10). Sometimes only one of these sacs communicates with the peritoneal cavity, the second being separated by a thin partition of peritoneum. In other cases both sacs open into the abdominal cavity.

FIG. 5.—HERNIA SAC. UPPER AND LOWER PORTION CONNECTED BY SMALL OPENING.

FIG. 6.—HERNIA SAC SEPARATED INTO TWO PARTS BY THIN MEMBRANE.

Contents of the Sac.—As we have stated, nearly every organ in the abdomen, with the exception of the pancreas, has been found in the sac of an inguinal or femoral hernia. The most frequent contents, however, are omentum, either alone or associated with the small intestine; the cecum, sigmoid, and more rarely the bladder, may be present. In femoral hernia the intestine is seldom found except in strangulation, the omentum forming the usual contents of the sac. Occasionally, however, the tubes and ovary and uterus have been found in the sac of a femoral hernia, and the appendix vermiformis has been found in one hundred cases.

The intestine and omentum are the most frequently found contents

FIG. 7.—HOUR-GLASS SAC.

FIG. 8.—HOUR-GLASS SAC.

FIG. 9.—DOUBLE SAC.

FIG. 10.—UNUSUAL TYPE OF SAC.

of the hernial sac. Some authors attempt to give the relative frequency of the parts forming the contents of the sac. Maydl,[2] in 283 cases of

inguinal hernia, found the intestine in 149; omentum in 77; both in 34 cases. In 123 cases of femoral hernia the intestine was found in the sac in 86, the omentum in 19, and both intestine and omentum in 14 cases.

It is obvious that this relative proportion must vary with the duration and size of the hernia. In the early stages of a hernia the omentum is the first to enter the sac; only after the opening has attained considerable size does the intestine enter. Hence, different statistics will undoubtedly show great variations in this respect. The small intestine more frequently enters the hernial sac than the large; the loop of intestine a short distance above the ileocecal valve, having the longest mesentery, is the most often found in the sac. It is probable, however, that in most cases the mesentery of other loops is sufficiently long to permit of their entering the sac of an inguinal or femoral hernia. The cecum and sigmoid are occasionally found in such sacs, although much less frequently than the ileum. In some cases, by reason of the fact that the cecum and sigmoid are almost completely surrounded by peritoneum, with an unusually free mesentery, they may appear in the hernial sac precisely as a coil of small intestine. In the majority of cases, however, they enter the hernial sac by a sliding process, forming a type of hernia characterized by the French as "hernie par glissement," or sliding hernia. In these cases the sac is incomplete, being absent posteriorly. Maydl found the large intestine in 22 of 443 cases, 11 of which were cecal.

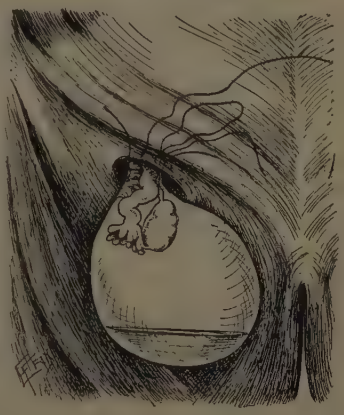

FIG. 11.—HERNIA SAC CONTAINING OVARY AND FALLOPIAN TUBE WITH ITS FIMBRIATED END, ALSO SMALL QUANTITY OF FLUID.

FIG. 12.—SLIDING CECAL HERNIA WITH HYDROCELE.

Etiology of Hernia.—Predisposing Causes of Hernia.—In addition to the presence of a funicular sac, or one of pre-natal origin, the following may be mentioned among the predisposing causes of hernia: Age, sex, heredity, occupation, obesity, pregnancy, certain constitutional diseases.

Age.—In a total of 75,544 cases observed at the Hospital for Ruptured and Crippled from 1890 to 1906 inclusive, 25,126 were below fourteen years of age; 4593 were between fourteen and twenty-one; 45,825 were over twenty-one.

Sex.—Of 70,090 cases of hernia 53,009 occurred in males and 17,081 in females, or 75.7 per cent. males to 24.3 per cent. females. Separately considered, we have the following proportion of males to females in the different varieties of hernia:

			Total.
Inguinal hernia	Male	48,254	56,980
	Female	8,726	
Femoral hernia	Male	990	3,404
	Female	2,414	
Umbilical hernia	Male	2,596	7,218
	Female	4,622	
Ventral hernia	Male	473	1,792
	Female	1,319	
Undescended testis (Usually associated with inguinal hernia)			687
Varicocele	Male	1,368	1,368
Hydrocele	Male	3,926	4,086
(Hydrocele) canal of neck	Female	160	

Berger,[3] in 10,000 cases of hernia observed by him, reports 7433 males and 2534 females, or about 75 per cent. of males to 25 per cent. of females.

Malgaigne's statistics published in 1836, show 2205 males to 564 females; in other words, 80 per cent. of male and 20 per cent. of female patients.

McCready[4] found 18,223 males to 3572 females, which, expressed in percentage, gives 84 males to 16 females.

It is difficult to understand these marked differences in the ratio of males to females, provided the facilities for treating both sexes are the same at the different institutions. In those clinics not provided with female assistants, undoubtedly many ruptured females would hesitate to apply for treatment, and, hence, the true ratio could not be ascertained from the statistics of such hospitals. At the Hospital for Ruptured and Crippled we have, during the past twenty years, had a female physician in attendance, and I believe that our statistics come near representing the correct ratio in dispensary practice.

The statistics of Malgaigne and Werkner[5] show 1 in every 21 subjects in Saxony examined to be ruptured, while in Belgium the proportion was found to be only 1 : 89. Berger estimates the proportion of ruptured in the male as one in 14.9, and one in 44.7 in the female, giving an average for both sexes of 1 : 22. He figures that in 30 per cent. of the male cases the hernia occurs during the first year of life; in 10 per cent. of the female cases. From ten to thirty-five years there is a minimum number, and from thirty-five to seventy there is a steady increase, the maximum being at seventy in the male, at sixty-five in the female.

Heredity.—At the Hospital for Ruptured and Crippled we have found that about one-fourth of all patients give a history of hernia in the family.

The predisposition to hernia seems to vary somewhat with different nationalities. According to the statistics of Baxter, based upon a study of cases observed in the United States army, the Portuguese are the most prone to hernia, and persons born in England and the United States are least so afflicted. These findings, however, can hardly be accepted as conclusive.

Obesity and pregnancy and general constitutional diseases which lessen the weight and cause atrophy of the abdominal muscles are all predisposing causes to hernia, especially umbilical hernia in adults. Berger's statistics show the marked influence of pregnancy upon the development of hernia. Eighty-one per cent. of single femoral hernias occurred in women who had borne children; 86.9 per cent. of double femoral hernias; 88.1 per cent. of umbilical, 89.6 per cent. of umbilical and inguinal, 100 per cent. of umbilical and femoral hernias.

Phimosis, which has been regarded by many writers upon hernia as an important predisposing cause, I am inclined to believe has no influence whatever. The same can be said of rickets and scoliosis.

Other Predisposing Causes.—Abnormal length of the mesentery has been believed by some writers to be a predisposing cause of hernia. Personally, I believe that it is of little importance. Given a preformed sac, or an open funicular process of peritoneum, there is always enough omentum ready to be forced into such a sac, in the presence of the particular exciting cause, which sufficiently increases the intra-abdominal pressure. The small portion of omentum acting like a wedge, enlarges the small funicular process or sac until it finally becomes a fully developed hernia, quite irrespective of the fact as to whether the mesentery be sufficiently long to enter or not.

The importance of a congenital or preformed sac as a predisposing cause of hernia I have already referred to somewhat at length.

The earlier operations for the radical cure of hernia were nearly all done upon adults, and upon hernias of large size, and in these statistics we find a much larger percentage of cases showing a sac continuous with the tunica vaginalis, or old type of congenital sac. Wood found this type of sac present 123 times in 370 cases.

At the Hospital for Ruptured and Crippled we have made a careful study of the type of sac in 2030 operations, 1507 of which were performed upon male children between four and fourteen years of age.[5a] The sac communicated with the tunica vaginalis in 369 cases, and in 626 cases it was of the funicular type, generally classed as acquired; in 522 the type of sac was not noted. There is every reason to believe, however, that in all of these cases the sac was preformed. These cases almost always give a history of the sudden appearance of a lump in the groin, being in exact accord with the theory of a preformed sac, distended by some unusual effort, and decidedly opposed to the theory that the sac was really acquired, caused by the gradual pressing forward of the parietal peritoneum through some weak place in the abdominal wall.

In direct hernia the predisposing cause is usually a defective development of the muscles and tendons which surround and guard the external ring, with an acquired sac in the majority of cases. This variety is far rarer than is generally supposed. Most of the early statistics which show a comparatively large relative number of direct hernias compared with oblique, are based upon non-operative cases observed in dispensary practice, and I am sure that a great many are classed as direct which are really oblique. The only accurate statistics are those in which the diagnosis is confirmed by operation. Such statistics show a very small proportion of real, direct hernias, as the author has observed only 44 cases in upward of 2030 operations, or 1 in 48.

In femoral hernia the predisposing cause may be an enlarged femoral ring, but, as Russell believes, and embryologic investigations seem to support such belief, there may be here also a congenital or preformed pouch or sac. The anatomic investigations of Murray confirm this opinion. He made a study of 100 post-mortem cases in individuals

(adults) who had had no hernia during life, and found 21 potential or empty sacs. Of these, 20 were femoral. The cases of femoral hernia in children under fourteen years, of which we have observed 90, furnish additional evidence.

Imperfect development of the internal oblique muscle has recently been brought forward, notably by Ferguson,[6] of Chicago, as the most common cause of inguinal hernia. While such defective development may possibly favor the formation of a direct hernia, I believe it plays little part in the development of oblique inguinal hernia.

In umbilical hernia the predisposing cause is always a congenital sac or an enlarged umbilical ring.

In epigastric hernia the cause is a slit or cleft in the fascia, of congenital origin, often transverse, through which the subperitoneal fat is frequently forced. This fat is apt to draw with it a slip of parietal peritoneum which forms the beginning of the hernial sac.

In view of the present confusion as to what is meant by congenital sac, I believe it might be well to abandon entirely the use of the term "congenital" as applied to any type of sac, and substitute, as suggested by Russell, the designations total funicular and partial funicular, to represent the two types of sac in inguinal hernia, the one communicating with the tunica vaginalis, the other being separate from it.

Exciting Causes.—Anything which increases the intra-abdominal pressure may be the immediate exciting cause of a hernia. The most common of these causes are lifting, straining, and coughing. Of 4621 cases of hernia examined by Berger with reference to the exciting cause, 1427, or 30.9 per cent. of patients, attributed the condition to some specific exciting cause. In 438 of these cases, such cause was supposed to be a fall or strained position, *e. g.*, a false step, from slipping or attempting to save one's self from a fall, thus putting an undue strain upon the abdominal muscles. Bronchitis and whooping-cough are often the immediate exciting cause in children.

A recent analysis of 5282 cases of hernia in adults observed at the Hospital for Ruptured and Crippled within the past three years, with reference to etiology, shows that of 502 cases of umbilical hernia in female adults, in 204 no known cause could be assigned to the development of the rupture; in 195 it was attributed to pregnancy; in 83, to strain; in 8, to coughing; in 6, to a fall; in 3, to obesity; in 2, to ascites; in one it was present since birth.

Of 4780 cases of hernia in adult males, over fifteen years of age, the cause assigned to the rupture by the patient at the time of admission was as follows: 3102 stated that the rupture appeared without any known cause; 1695 attributed the hernia to a specific exciting cause; of these, 1015 stated that the hernia was due to lifting or carrying some heavy weight; 150 were due to coughing or sneezing; 123, to strain; 89, to falls; 40, to blow on groin or abdomen; 14, to local trauma of some kind; 8, to kicks; 51 had been noticed from birth. The remainder assigned the condition to various causes.

Local trauma, which has long been accorded by the laity an important place in the etiology of hernia, practically very rarely is the cause.

Given the conditions already described, namely, a preformed sac, it is conceivable that an accident in the way of a fall, or of a heavy weight striking upon the abdomen, resulting in greatly increased intra-abdominal pressure, might act as an exciting cause, but there is little evidence that a direct trauma, *e. g.*, a blow or local injury in the region of the hernial orifices, produces a hernia. There are, however, a number of authentic cases on record in which a hernia has developed immediately after a local trauma—*e. g.*, the kick of a horse—in persons hitherto in perfect health, without any previous history of a hernia, and, as far as known, without any predisposing cause other than the probable existence of a preformed sac.

Industrial accidents of various sorts, unusual lifting or straining or false position, causing greatly increased intra-abdominal pressure, are much more frequently regarded as the cause of a hernia than the actual facts warrant. While in many of these cases such industrial accidents must be looked upon as an actual exciting cause, in the great majority there will be found a congenital weakness in the way of a preformed sac and, probably, in addition, an enlarged ring or weakened muscles.

The question of the relation of industrial accidents to the development of hernia is growing in importance from a medicolegal standpoint. In most of the European countries the courts have decided that hernias may be due to industrial accidents, and, therefore, are subject to an indemnity. To prove this causal relationship, the hernia must have been examined very soon afterward (within forty-eight hours) by a physician, and must present evidences of its recent origin. Proof of a predisposition, congenital or acquired, in most cases has influenced the courts to lessen the indemnity.

Kaufmann, of Zürich, has made a careful study of the question, based upon medical jurisprudence. These are his conclusions:

A hernia, in order to be entitled to an indemnity, must be of recent origin; it must appear suddenly, must be accompanied by pain, and must immediately follow an accident. There must be proof that the hernia did not exist prior to the accident.

Diagnosis of Hernia.—The diagnosis of reducible hernia is not difficult and can usually be made from the following physical signs:

The presence of a tumor in the region of one of the natural abdominal outlets, *e. g.*, inguinal, femoral, or umbilical regions, which disappears on lying down or can be reduced by manipulation or taxis, and has a distinct impulse on coughing. There are two conditions, however, which may closely simulate a reducible hernia: *saphenous varix* and *varicocele*, the first being often mistaken for a femoral, the latter for an inguinal, hernia. These conditions may, however, be easily differentiated from hernia if the following rules be noted: Saphenous varix may closely resemble a femoral hernia in size, shape, and location; furthermore, like a hernia, it disappears on lying down and has a distinct impulse on coughing. It differs from femoral hernia, however, in these two important points:

1. The character of the impulse is quite different: instead of an impulse suggesting a solid body being propelled against the fingers, it has a peculiar thrill, as if fluid were being forced through a compressible tube beneath the fingers.

2. If the tumor is reduced and the fingers are pressed over the femoral opening,—not too strongly, but sufficiently hard to prevent the contents of a hernia, *e. g.*, bowel or omentum, from being forced out,—and the tumor nevertheless slowly re-forms, it is a saphenous varix. Another important clinical aid to the diagnosis of saphenous varix is the fact that in nearly every case examination of the lower extremity will show the presence of well-marked varicose veins. The same rules will apply to varicocele in enabling one to differentiate the condition from inguinal hernia.

Irreducible and Strangulated Hernia.—Most of the errors in diagnosis are made in cases of irreducible hernia, and here many difficulties are encountered. The condition most often mistaken for irreducible inguinal hernia is hydrocele. At the Hospital for Ruptured and Crippled 4086 patients with hydrocele applied for treatment under the supposition that they were suffering from hernia (in a total of 75,544).

Other conditions simulating more or less closely irreducible hernia are lipoma, inguinal or femoral adenitis, cysts, cold abscess from tuberculosis of the pelvic bones or vertebras.

General Symptoms.—These depend somewhat upon the anatomic variety under consideration, also upon the age of the patient. In inguinal hernia, especially in children, the hernia is usually first noticed by the mother, in the absence of any particular subjective symptoms. A lump is found in the groin, usually while bathing the child. This lump is sometimes present, at other times absent. Pain, which is a fairly constant feature in the early stages of hernia in adults, is rarely present in children, or is too slight to be noted.

In most cases of hernia in adults, as I have stated, I believe there is present a preformed or potential hernial sac; it is probable, however, that in such cases the sac is so small and slender that it requires a good deal of dilatation before it can accommodate a fully developed hernia. Hence, we have more pain in these cases. This pain is of the dull, dragging variety, seldom sharp and acute; rarely severe enough to cause the patient to consult a physician. Some weeks or months later, the patient notices a lump in the groin which can easily be pressed back or disappears spontaneously on lying down. The tumor, or hernia, for such it is, if not controlled by a truss, gradually increases in size, until it finally enters the scrotum. The pain and discomfort are always worse at night, or after standing or walking for several hours.

In certain cases digestive disturbances may occur as early symptoms, even before the hernia has attained sufficient size to attract the attention of the patient. In these cases a careful physical examination will show the presence of an incomplete hernia, and application of a truss will usually cause the disappearance or cessation of the symptoms.

Physical Signs.—The first thing noticed is a tumor of varying size and consistence, according to its duration and contents. If intestine

be present, we have a tumor of smooth outline, elastic on palpation and resonant on percussion. If reducible, the swelling goes back with a characteristic gurgle. If irreducible, the tumor usually quickly shows signs of strangulation, though occasionally the cecum or large intestine may remain irreducible in the sac for a considerable time without becoming strangulated; likewise in very large umbilical hernia with a wide-necked sac, a loop of intestine may be irreducible without strangulation occurring. If omentum alone be present in the sac, palpation will reveal a tumor more irregular in outline, firmer in consistence, and, on pressure between thumb and fingers, the characteristic "feel" of omentum can be easily made out. If the hernia cannot be reduced by reason of adhesions between the omentum and sac, the tumor is apt to be harder and more nodular, owing to inflammatory changes in the omentum. In some cases of this kind connection with the abdominal cavity may be shut off completely by adhesions between the omentum and the neck of the sac, and the sac itself may be distended by inflammatory exudate. In such cases the tumor closely resembles a hydrocele. The omentum is much more likely to become adherent in femoral than in inguinal hernia, and in oblique than in direct hernia. In many cases, in the early stages of a hernia, the tumor is noticed only on coughing or straining.

Differential Diagnosis.—The conditions that most often simulate a hernia are lipoma, adenitis, cold abscess, hydrocele, varicocele, saphenous varix, and cysts.

Lipoma may very closely simulate a femoral hernia, but the diagnosis may usually be made by the fact that the tumor is more superficial, more movable, and cannot be traced directly into the femoral canal. Again, there is never a history of previous reducibility, as is nearly always the case with hernia.

Adenitis.—Inguinal and femoral adenitis have been mistaken for hernia by surgeons of large experience. Ordinarily the diagnosis is easily established. Tenderness, infiltration of surrounding tissues, a history of short duration, together with the fact that at no period was the tumor reducible, will be sufficient to rule out a hernia. Besides, careful examination will usually reveal some cause for the adenitis, *e. g.*, acute or subacute gonorrheal infection, or some abrasion upon the skin of the leg or foot. There are cases of adenitis, however, of a subacute or chronic character, especially those of tuberculous origin, in which it is almost impossible to differentiate the condition from irreducible omental hernia. This is true more often in the femoral than in the inguinal variety. The history of reducibility in the early development of the swelling may be the only point to aid one in making the diagnosis. I have observed several cases of small, irreducible, omental femoral hernia, the size of an English walnut, which had been down for years and in which the omentum had undergone partial cystic degeneration, giving rise to fluctuation. Such cases so closely resemble adenitis that it is extremely difficult to make the differentiation. In all such cases it is most important to study the history of the case as well as the physical characteristics before making the diagnosis.

Cold abscess from tuberculous osteitis of the vertebra, or from one of the pelvic bones, in certain cases very closely resembles a hernia. A number of such cases diagnosed as hernia by physicians have been sent to the Hospital for Ruptured and Crippled for a truss. When the tumor appears in the femoral region it resembles very closely a femoral hernia; it disappears on lying down and reappears on standing or coughing; furthermore, it has a distinct impulse on coughing. It can always be differentiated, however, from femoral hernia, from the following points:

1. Palpation easily discloses the presence of fluctuation, which is a very rare condition in reducible femoral hernia, and I have never seen it except in the presence of abdominal ascites.

2. Deep pressure in the iliac fossa with one hand, while at the same time the tumor is reduced with the other hand, will show that the fluid is not reduced into the free abdominal cavity, but will disclose a sac or pouch in the iliac fossa, behind the peritoneum. Bimanual pressure shows that the two swellings, external and internal, communicate, and that fluctuation is easily transmitted from one to the other. This rules out every form of hernia except the intraparietal variety with a bilocular sac, but so large an amount of exudate would be possible in such a type of hernia only in strangulation, the presence of which would show distinct symptoms. While the diagnosis of cold abscess is now fairly clear, it can usually be fully confirmed if we examine the patient's back. We shall generally find a kyphosis, showing the presence of tuberculous osteitis or disease of the vertebra. If the disease is not sufficiently far advanced for this, we may find marked rigidity in the spine, which will enable us to locate the lesion.

FIG. 13.—TUBERCULOUS ABSCESS OF OS PUBIS, GIVING SOME SIGNS OF AN INGUINAL HERNIA.

Cold abscess in the inguinal region may be due to tuberculous osteitis of the pubic bones. I have seen several such cases. A careful history of the case, together with the fact that the anatomic location of the swelling does not exactly correspond to that of an inguinal hernia, will enable one in nearly every instance to make a correct diagnosis.

Cysts.—Cysts in the inguinal or femoral region may be mistaken for hernia, but the condition is extremely rare, and only cysts of Bartholin's gland, simulating a labial hernia, could come into consideration. I have seen but one such case, and the diagnosis there could be easily

made by the fact that the tumor began to develop low down in the region of the vulva and, as it increased in size, gradually occupied the position of the external ring, but did not enter the canal. Such cysts may attain considerable size, the one referred to having reached the size of a large orange. Careful examination will show the inguinal canal empty.

Treatment of Hernia.—Hernia may be treated by either of two methods, mechanical or operative.

Mechanical Treatment.—By mechanical treatment we mean attempts to control the hernia by some form of apparatus, such as a truss or belt—a truss for inguinal and femoral hernia, a belt for umbilical hernia. Before applying a truss, the hernia should always be completely reduced. In case of a large hernia, this can best be accomplished with the patient in a prone position. In large scrotal hernia it is often necessary to use a perineal strap to hold the pad in exact position over the opening. The best types of truss are those made with a metal spring, either steel or aluminium covered with leather or hard rubber. In applying any form of truss the pad should be so placed as to rest directly over the internal ring, rather than the external, where it is likely to press upon the cord as it passes over the pubic bone. The pad should be slightly convex in shape, covered with leather. In some cases very difficult to control a water pad has proved more efficient than a solid pad. Femoral hernia is best controlled by a French type of truss. (See Figs. 15 and 18.) This type is also best adapted to inguinal hernia in the female during pregnancy.

Fig. 14.—The Frame Truss.

Fig. 15.—The French Truss for Femoral Hernia.

The Knight (cross-body) truss, with a short shank projecting at right angles from the steel spring, is the form used at the Hospital for Ruptured and Crippled for the last forty years. It consists of a steel spring so tempered as to admit of slight bending, covered with rubber tubing, passing three-fourths of the distance around the abdomen, the remaining fourth being completed by a strap. It has the advantage of being applicable to femoral as well as inguinal hernia. The amount of pressure can be easily regulated by bending the spring and a perineal strap can be readily applied if necessary. In private practice the Hood or frame truss, of which the Pomeroy is a good example, is one of the most efficient and most comfortable (Fig. 14).

Fig. 16.—Abdominal Belt.

Umbilical hernia in adults is best controlled by a belt (Fig. 16) made either of linen duck or woven silk elastic. Care must be taken not to make the front of the belt too concave, as in most cases there is needed, in addition, a pad, circular or elliptical in shape, of about 2 inches greater

diameter than the hernial ring. The pad should be fastened to the belt in such a way that, if the latter is in position, the pad will rest directly over the hernial orifice. In case of irreducible or partially reducible umbilical hernia, the pad may be made slightly concave.

FIG. 17.—THE KNIGHT TRUSS USED AT THE HOSPITAL FOR RUPTURED AND CRIPPLED.

In umbilical hernia in children no form of belt is satisfactory, for the reason that it cannot be made to retain its position. The best way to control umbilical hernia in children is by means of a strip of zinc oxid adhesive plaster, 2 inches in width, placed so as to entirely encircle the abdomen on a level with the umbilicus. A wooden button mold 1½ inches in diameter, covered with adhesive plaster, forms an excellent pad.

The mechanical treatment of irreducible inguinal hernia is difficult and unsatisfactory. The so-called hinged-cup truss, devised by Kingdon, may in such cases be useful, especially in cases in which the omentum alone is adherent. The use of some such apparatus may prevent the intestine from entering the hernial sac. Most cases of irreducible hernia should be subjected to operation, unless there be strong contraindications, *e. g.*, the coexistence of organic trouble of the kidney or heart, the advanced age of the patient, or the great size of the hernia. In those cases in which operation seems unwise, our efforts should be directed toward preventing further increase in the size of the hernia and toward securing the greatest amount of comfort for the patient. In many cases all that we can do is to adjust a well-fitting scrotal bag, made of canvas or some other unyielding material, which is held firmly against the body by a strap encircling the pelvis and supported by another strap from the shoulders.

FIG. 18.—THE FRENCH TRUSS FOR FEMORAL HERNIA.

In infants or young children a worsted or yarn truss has been highly recommended by some writers. We have given it an extensive trial at the Hospital for Ruptured and Crippled, and discarded it for the reason that it is less efficient than the spring truss and much less cleanly. There is no better truss than a well-tempered spring truss, and

if such truss is properly fitted, it causes no more discomfort to the infant than the worsted truss. The truss should be applied as soon as possible after the discovery of the rupture, no matter how young the infant. Although there is a tendency at present toward extending operative treatment to an earlier and earlier period of life, some surgeons advocating operation upon the youngest infants, I believe such practice unwise. My reasons are: (1) That a large number of infants and young children under the age of one to two years are permanently cured by mechanical treatment; hence, if all cases below this age were operated upon, many unnecessary operations would be performed. (2) Operation in infants and very young children is attended with a higher mortality, as the statistics of Stiles and others have shown. I believe that operation is seldom indicated under the age of four years, although there are certain cases, *e. g.*, those associated with reducible hydrocele, in which the rupture cannot be controlled with a truss, in which operation is justifiable at a younger age.

General Prognosis.—In the majority of cases a hernia of small size, if properly fitted with a truss, may be kept from increasing in size, and the individual may be able to perform most kinds of work without material discomfort. In a certain number of cases, however, the hernia may escape beneath the truss, by reason of some unusual abdominal effort and strangulation may occur. In femoral hernia, in spite of a truss, a small portion of omentum is very apt to get into the hernial sac and then it quickly becomes adherent. The same is true, even to a greater degree, of umbilical hernia. The prognosis of irreducible hernia is graver than that of simple reducible hernia. In umbilical hernia the omentum, though adherent, does not prevent the intestine also from finding its way into the hernial sac, and this may likewise become adherent, causing attacks of temporary obstruction, inflammation, or complete strangulation.

FIG. 19.—THE RAT-TAILED TRUSS FOR VERY LARGE HERNIA.

Radical Treatment of Hernia.—The introduction of subcutaneous surgery by Stromeyer in 1835 marks an important era in the history of the operative treatment of hernia. Among the earlier methods may be mentioned Wutzer's and Gerdy's, and the method of John Wood, of London, which was a combination of the open and subcutaneous methods. Wood's method was introduced in England in 1857. The mortality following his procedure was 7 per cent.

By modern methods of operation for the radical cure of hernia we mean those introduced or reintroduced after the great discoveries of Lister and Pasteur. The first operation for the radical cure of hernia after the introduction of antisepsis was that of Richard Steele, of London, in 1874, followed by Czerny's in 1877, Marcy's in 1878, and Championnière's

in 1881. While the immediate results of some of these methods were very good, particularly in the hands of their originators, the sum total of results was far from satisfactory, and there was in 1890 a strong tendency on the part of the more conservative surgeons to regard with doubt the claims of any of the methods to the designation "the radical cure of hernia," for the reason that the statistics of the most reliable sources showed a proportion of 30 to 40 per cent. of relapses within the first year. In addition, the risk of operation for hernia at this time was by no means to be ignored. Four of the largest hospitals in London in 1890 showed a mortality of 6 per cent. The enthusiasm for the radical cure of hernia was beginning to wane when the methods of Halsted and Bassini were published (1889–1890).

The two methods differ in several important points: In Halsted's method the cord is transplanted more externally, so that it lies just beneath the skin and superficial fascia, whereas in Bassini's operation the cord is covered by the aponeurosis of the external oblique as well as the skin and fascia. The most important difference, however, is that in the Halsted method the internal oblique muscle is cut upward 1 or 2 inches before it is sutured to Poupart's ligament. The results of operation have shown this step to be entirely unnecessary. In many cases, I believe, the cutting of the internal oblique greatly increases the chances of recurrence, as it weakens the very structure we most rely upon for a radical cure. Another point of difference is the resection of all but one or two veins of the cord. Here again the results, showing atrophy of the testicle in a considerable proportion of cases, have proved the disadvantages of the method.

The unquestionable superiority of Bassini's method over the earlier methods, as well as over most of those since devised, is shown by the fact that this operation with slight modifications is today the operation of choice in practically all the clinics of the world. The secret of the success of Bassini's operation, I believe, depends largely upon the fact that it was the first operation in which the attempt to cure the hernia was based upon a true appreciation of the etiology of hernia. In none of the earlier methods except Championnière's was it possible to thoroughly remove the sac flush with the peritoneal cavity. At present we are beginning to appreciate the fact that the great predisposing cause in all inguinal and probably the majority of femoral hernias, is a congenital or preformed sac, and on basis of this, the first and essential principle of a radical cure must be the thorough removal of such a sac.

Principles Underlying Operative Treatment.—Ligature of the sac and suture of the external pillars of the canal: Czerny, Banks, Barker, McCormac. Suture of the canal with overlapping of the aponeurosis of the external oblique: Championnière. Infolding of the sac to form a pad within the internal ring: Macewen. Torsion of sac and suture in the canal: Ball. Torsion of sac and suture outside of aponeurosis: Kocher. Slitting up of the canal; high ligation of sac; wound left open to heal by granulation: McBurney. Slitting up aponeurosis of the external oblique; high ligation of sac with transplantation of cord; and suture of

the internal oblique to Poupart's ligament: Bassini, Halsted. Transplantation of the cord by cutting through the transversalis fascia and severing the epigastric vessels: Fowler.

The methods or modifications of methods for the radical cure of hernia introduced in recent years are so numerous that no attempt will be made to describe them. Many of them differ so slightly that they do not merit separate names, and the majority of them depend upon a few general principles that have long been recognized.

Indications for Operation.—The results of modern methods of operation performed under the best conditions show a very slight mortality (0.25 to 0.5 per cent.) and a very large percentage of permanent cures (upward of 95 per cent.).

Truss treatment seldom effects a cure of the hernia, except in the very young. In view of these facts, we are warranted in advocating operation in practically all cases, with the following important exceptions: (1) Infants or children under the age of three to four years; (2) the very aged, unless the hernia is in danger of strangulation; (3) very large irreducible hernia (especially in stout individuals); (4) persons with grave constitutional disease.

Choice of Method.—Only those methods should be employed that have stood the test of time. With equally good results, that method should be selected which is the simplest as regards technic and safest as regards risk of life. At present the evidence is very strongly in favor of Bassini's method, with or without the transplantation of the cord. Some procedures have yielded good results only in the hands of their author, but with Bassini's method equally good, if not superior, results have been obtained by other surgeons. While the results of Kocher's method at the Bern clinic have been nearly as good as those obtained by Bassini's method, the former seems theoretically inferior to Bassini's method, and, practically, I do not think it is applicable to such a wide range of cases as Bassini's method.

There is some uncertainty as to the wisdom of transplanting the cord as a routine measure. Experience thus far would seem to show that it is immaterial in the case of children, but in adults I believe that slightly better results may be obtained by retaining the transplantation step. Transplantation of the cord is essential to success in all cases of direct inguinal hernia. On the other hand, in cases of oblique hernia associated with undescended testis transplantation should always be omitted in order to obtain greater length of cord.

In my opinion, the curved skin incision which is advocated by some writers is distinctly inferior to the straight incision; it requires more time in closing and also leaves a much more noticeable scar. That feature of any method which allows the sac to remain behind to be disposed of in various ways, either extraperitoneally or intraperitoneally, has, I believe, little to commend it. Such disposition of the sac somewhat lessens the chances of securing primary union and affords no additional security against relapse.

Success in any method for the radical cure of hernia depends in no

small degree upon rapidity of operating and careful dissection, without bruising the tissues, both of which features greatly facilitate primary union.

The use of rubber gloves is a most important element in the technic of hernia operations. Their employment does not lengthen the time of operation, as claimed by some, and certainly lessens the chances of infection. Since the introduction of rubber gloves at the Hospital for Ruptured and Crippled, primary union has been obtained in 98.5 per cent. of the cases.

The choice of suture material is next in importance to the choice of method. Many of the earlier failures were undoubtedly due to too rapid absorption of simple catgut sutures. On the other hand, many of the later failures have been due to the use of non-absorbable sutures, which caused the development of slowly healing sinuses, finally weakening the line of union of the deep sutures to such an extent that relapse followed. Upward of thirty cases of sinus formation have been observed at the out-patient department of the Hospital for Ruptured and Crippled following the use of silver wire, silkworm-gut, and silk. In some of the cases that healed by primary union a sinus developed as late as nearly four years after the introduction of the sutures. Now that it has been proved possible to thoroughly sterilize absorbable sutures of kangaroo tendon or catgut, and to so chromicize them as to cause them to remain unabsorbed for any desired length of time, I believe there are no longer any valid reasons for continuing the use of unabsorbable sutures in operations for the radical cure of hernia. A word of caution is, however, necessary in regard to the use of the commercial catgut, especially the larger sizes. The writer knows of two cases within the last year in which the patient died of tetanus from the use of imperfectly sterilized catgut. This fact might be used as a reason for using non-absorbable sutures. It certainly would seem preferable to use such sutures, rather than catgut of doubtful sterility. At the Hospital for Ruptured and Crippled, during the last seventeen years, all chromicized kangaroo tendon and catgut used has been prepared by Van Horn & Sawtell, and frequent bacteriologic examinations have always shown it to be sterile. There are many methods of preparing catgut at the present time which render its use absolutely safe.

Local Anesthesia.—Local anesthesia was at first advocated for strangulated hernia, but at present a number of surgeons strongly urge its adoption as a routine measure in all operations for the radical cure of inguinal hernia. Cushing and Bloodgood, of Johns Hopkins, and Bodine, of New York, have been among its earliest and strongest advocates. Bloodgood states that in 18 per cent. of the cases of strangulated inguinal hernia, 28 per cent. of those of strangulated femoral hernia, and 33 per cent. of those of strangulated umbilical hernia observed at the Johns Hopkins Hospital the intestine was gangrenous or general peritonitis was present at the time of operation, and in 25 per cent. of these cases bronchopneumonia was noted at autopsy. Ether was the anesthetic used in all cases. If cocain were used in such cases, and a

simple operation first performed, he believes the mortality would be lower.

Cushing, in 1900, reported forty-nine cases of hernia in which cocain had been used at the Johns Hopkins Hospital. Cushing advised its use only in the presence of certain conditions, *e. g.*, advanced age, chronic bronchitis, laryngitis, cardiac disease, and chronic nephritis, but regarded general anesthesia as preferable, from the standpoint of both surgeon and patient, when it could be given with safety.

Bodine,[7a] of New York, has operated upon 500 cases of non-strangulated hernia under cocain anesthesia with remarkably good results. He has had no mortality and the wound healing and final results have been apparently as good as have been obtained under general anesthesia.

The advantages claimed for the method are that it avoids the risks of a general anesthesia. I do not believe, however, that these risks are any greater than those of cocain, considering the increased risk of the latter from sepsis due to the prolonged exposure of the wound, the operation under cocain taking about one hour, while under a general anesthetic the same operation can be performed in ten minutes. I believe that local anesthesia has a very important place in hernia operations, but would restrict its use to cases in which ether is contraindicated. The danger from the small amount of ether required for a hernia operation in a healthy individual I believe to be practically *nil*. We have had only one death from ether in over 2200 cases at the Hospital for Ruptured and Crippled, and this from bronchopneumonia in a child who had recently recovered from an attack of measles, in which it would have been wiser to postpone operation until a later date. Adding to these my cases operated upon outside of the Hospital for Ruptured and Crippled, the number would exceed 3200 cases, with one death from anesthesia.

The dangers from cocain cannot be entirely disregarded, although in the minute doses recommended by Bodine the risk is doubtless exceedingly small. Some surgeons, notably Bier, have recommended and use spinal anesthesia (cocain, eucain, novocain, etc.) for all operations for inguinal hernia, but up to the present moment the dangers of spinal anesthesia, even in the hands of the most expert, are certainly far greater than the dangers from ether. Hence, I do not believe it should be substituted for general anesthesia as a routine measure.

The question of local anesthesia for strangulated hernia has been recently discussed by Hesse, of Bruns' clinic. While he believes that, on the whole, it is preferable to general anesthesia, he admits that it makes greater demands on the mind of the patient, and the danger of shock, so frequently pointed out by v. Bergmann and Lexer, cannot be ignored. While Hofmeister and Petersen are strongly in favor of local anesthesia in strangulated hernia, Mikulicz and Henle[8] were equally opposed to it, and do not believe the dangers from pneumonia are lessened by its use.

Dangers Connected with the Operation for the Radical Cure of Hernia.—Most of the deaths from hernia operations have been due

to infection, but with the gradual perfection of technic, especially since the use of rubber gloves has become more general, the mortality has steadily decreased. Up to 1890 the mortality from operation for non-strangulated hernia in four of the largest hospitals in London was 6 per cent. In 2032 cases operated upon at the Hospital for Ruptured and Crippled from 1890 to 1907, there have been five deaths.

The danger of pneumonia is very slight in a healthy individual; the patient is under the anesthetic for not more than ten to fifteen minutes in uncomplicated cases. A certain number of deaths have been reported as due to embolism; three deaths due to tetanus from the use of imperfectly sterilized catgut sutures have come to my notice.

I know from personal communications of four instances of injury to the artery or vein from needle puncture during the insertion of the deep sutures into Poupart's ligament. If these sutures are always introduced from within outward, the danger of injury to the vessels will be reduced to a minimum. Although I always use a sharp Hagedorn needle, I am extremely careful not to go too deep, and always pick up the shelving process of Poupart's ligament with forceps before inserting the needle, and, most important, always insert it from within outward, or, rather, from below upward.

The extensive statistics of Pott[9] show the mortality of inguinal hernia prior to 1894 to be 1.9 per cent.; since 1895, 0.7 per cent.; of femoral hernia prior to 1894, 2.1 per cent.; since 1895, 0.5 per cent.; of ventral hernia before 1894, 3 per cent.; since 1895, 1.1 per cent.

Of 129 cases in which the cause of death was stated, it was due to septic processes in 43 cases, or 30.9 per cent., *i. e.*, peritonitis was the cause in 22 cases; erysipelas, in 4 cases; tetanus, in 2 cases.

Acute lung complications, pneumonia, bronchitis, were present in 42 cases (30.9 per cent.). Death was attributed to chloroform and ether in 8 cases; to iodoform in 1 case; to intestinal complications in 11 cases; to post-operative hemorrhage in 8 cases; to embolism in 8 cases; to uremia in 2 cases; to shock in 2 cases.

ACCIDENTS OF HERNIA.

Among the most important may be mentioned: Obstruction, irreducibility, inflammation, strangulation.

Obstruction.—Fecal stasis was at one time regarded as a very common occurrence and one of the most frequent causes of strangulation. Modern writers either deny the existence of fecal stasis or believe it to be extremely rare, occurring only in irreducible hernia of the large intestine of long standing. They deny that it is ever the actual cause of strangulation. I have observed one case of strangulated sigmoid hernia in a child three and a half years of age, in which the fecal accumulation was the chief cause of strangulation. In this case a loop of bowel 6 inches long was completely filled with fecal matter of the consistence of putty. The diagnosis was made before operation. This is the only

instance which I have personally observed and very few have been reported.

Symptoms.—The symptoms of obstructed hernia are milder in type and develop more slowly than in strangulation. Constipation is present, but not obstinate. The tongue is usually coated; the patient loses desire for food; nausea and often slight vomiting may be present. There is usually a dull, dragging feeling in the region of the hernia which, later on, may become actual pain, acute and colicky in character, and finally extend over the whole abdomen. Examination of the tumor at this time shows it somewhat larger than usual and slightly tender on pressure; an impulse on coughing may usually be detected, particularly in the upper portion of the tumor. These symptoms may last for several days without any material increase in severity and then gradually disappear. In certain cases, however, they continue, become more and more severe, and finally end in strangulation. If no improvement follows the administration of enemata, one should suspect strangulation and act accordingly.

Treatment.—The treatment depends largely upon the severity of the symptoms. In nearly all cases taxis is injudicious and may be harmful. The patient should be placed in bed, the foot of the latter elevated, and external applications—preferably of hot cloths, frequently changed—should be made to the hernia. Cathartics should not be given by the mouth, but an attempt should be made to move the bowel by high enemata, consisting of oil and ox-gall, followed by 1 or 2 quarts of warm water, and repeated every two to three hours. If the bowels have been partially moved by enemata, it is safe to give a cathartic by mouth, preferably a small dose of calomel followed by saline. In the event of failure to relieve the obstruction, the case should be treated as one of strangulation, with immediate operation.

Irreducible Hernia.—This term is applied to a hernia in which the contents of the sac cannot be returned into the abdominal cavity, but in which the constriction is not sufficient to interfere with circulation or with the function of the omentum or bowel. This condition of irreducibility may be due to a sudden increase in the size of the hernia resulting from some unusual muscular effort, or, as is more often the case, it may be due to the fact that it has been incompletely controlled so long that adhesions have formed between sac and contents, thus preventing the return into the abdomen. This condition is most frequently found in umbilical hernia; second, in the order of frequency, in femoral; and, third, in inguinal hernia. Macready found in 377 cases of irreducible inguinal and femoral hernia observed at the London Truss Society, 187 cases of inguinal and 190 of femoral hernia.

Irreducible hernia rarely occurs in children under the age of fourteen; the only cases observed at the Hospital for Ruptured and Crippled have been in sliding cecal hernias. The contents of the sac in irreducible hernia in children is nearly always the cecum or sigmoid. In adults it is the omentum in 90 per cent. of the cases. Serous exudate is often

found in irreducible hernia in varying amounts, dependent upon the tightness of the constriction.

Symptoms.—In the cases of irreducible omental hernia there are few symptoms worthy of note, unless the mass of omentum be very large, in which case there is often a dragging sensation or feeling of discomfort by reason of the weight.

In irreducible umbilical hernia, especially in stout people, there is very apt to be a portion of the colon as well as of the omentum in the hernial sac, and in such cases there are often present colicky pains, flatulence and digestive disturbances, associated with marked irregularity of the bowels. Not infrequently attacks of local peritonitis occur, confining the patient to bed for a number of days. Such a condition is attended with considerable risk, inasmuch as the simple irreducible hernia has become an inflamed one, and the treatment will be considered under the heading of inflamed hernia.

Fig. 20.—Special Truss for Very Large Inguinal Hernia.

Treatment.—If the hernia has been irreducible for only a few days or weeks, rest in bed with the application of an ice-bag, with pressure from a firmly applied bandage, may be sufficient to render possible the return of the hernia into the abdomen. During the period of rest in bed the patient should be put on a strict diet, especially if inclined to stoutness. Taxis should be tried every two or three days, but never pushed to the limit of causing inflammatory changes in the contents of the sac. Macready believes that much can be accomplished in inguinal hernia by the use of the hinged-cup truss. He states that 68.7 per cent. of irreducible inguinal hernias can be reduced by this truss if worn day and night, the average time required being about fifty days. (See Fig. 20.)

The difficulty in the way of practical application of such methods of treatment lies in the fact that very few individuals are willing to submit to the long period of enforced rest necessary to insure success. Even in the event of a successful reduction of the hernia such cases are usually most difficult to control; hence the liability to become again irreducible.

Personally I believe it is far better in these cases to advise operation, except in a small number of cases in which there are sufficient contra-indications to operative treatment.

Inflamed Hernia.—A hernia that has been irreducible for a long

time soon becomes adherent, and from the action of a truss or the constant irritation caused by walking it may become inflamed. In some of the cases, although this rarely happens, it may become infected with the colon bacillus or other pyogenic organisms and suppuration in the sac may take place. I have had recently a case under treatment at the General Memorial Hospital, a woman sixty years of age, with a large irreducible umbilical hernia in which suppuration occurred, causing rupture of the sac, infiltration of the overlying skin, breaking externally and discharging about a pint of pus and necrotic omentum. Bacteriologic examination showed a pure culture of colon bacillus. The patient made a good recovery, without operation.

The heavy weight of a hernia may cause marked changes in the circulation, giving rise to venous stasis. In most cases the inflammation is of a simple type, causing adhesions between the omentum and the sac.

The chief causes of inflamed hernia are prolonged taxis, causing extravasation of blood, contusion, pressure from an ill-fitting truss, enteritis, obstruction. The inflammation may begin in the wall of the sac or in the contents of the same: in either event both sac and contents are usually quickly involved in the process. The sac becomes filled with serous exudate, which may either disappear entirely by absorption, or go toward the formation of adhesions. The process is really one of local peritonitis, resulting ordinarily in complete resolution, but occasionally ending in strangulation.

Symptoms.—In the more acute types we find local tenderness, increase in size, presence of an exudate, as shown by fluctuation and slight febrile reaction. In some rare cases the skin may become reddened and adherent; there may be an increased pulse-rate, nausea, constipation, and sometimes vomiting. If the omentum alone is contained in the hernial sac, the symptoms are of a less severe type and of short duration. If, however, the bowel be present in the hernial sac, the condition is far more serious.

Treatment.—The application of ice or hot towels. Ice should never be used in elderly persons. High enemata, such as advocated in cases of obstructed hernia, are here indicated, and no cathartics should be given until the bowels have been moved.

Strangulated Hernia.—By "strangulated hernia" we mean a hernia that has become so tightly constricted as to seriously interfere with the circulation of the viscus forming the contents of the hernia. If the constriction is not relieved within a comparatively short time, gangrene inevitably follows.

Etiology.—The ring which forms the constriction may be an opening in the fascia through which the hernia protrudes, *e. g.*, a tight external ring in inguinal hernia, or the crural ring in femoral hernia, or it may be the neck of the sac. The neck of the sac has been given a far more important rôle in strangulated hernia than the facts justify. In children it is almost never the cause of strangulation, the constriction being due to a tight external ring in the great majority of cases. In seventeen cases of strangulated hernia in children at the Hospital for Ruptured and Crip-

pled the strangulation was due to the neck of the sac in only one instance, a boy three years af age.

Mechanism of Strangulation.—Much study has been given and many experiments have been made in efforts to determine the mechanism of strangulation. Even at the present time authorities are by no means in accord. The problem is difficult of solution for the reason that it is impossible to artificially produce in animals the exact conditions present in the case of strangulated hernia in man. The most important of the theories thus far advanced are those of Roser, Busch, Lossen, Kocher, and Reichel.

Roser, in 1856, believed that constriction was due to a valve-like occlusion produced by folds of mucous membrane at the site of the constriction.

Busch's theory, 1875, was that the fluid contents of the intestine were

FIG. 21.—MECHANISM OF STRANGULATION.
1, Theory of Busch; 2, theory of Lossen; 3, theory of Berger (interposition of mesentery).

forced into the afferent loop, producing angulation, which was an important cause of strangulation.

Lossen explained the mechanism of strangulation as due to compression of the column of feces acting upon the vessels of the mesentery, producing venous stasis.

Kocher (1877) considered dilatation of the intestine, rather than angulation, to be an important factor.

Reichel (1886) offered still another explanation, namely, that the mucous membrane of the constricted loop was forced upward by a process of invagination, thus becoming an important element in strangulation.

Van Zwalenburg, of Riverside, Cal., has recently carried out some interesting experiments bearing upon the etiology of strangulated hernia, which, though unpublished, I am permitted to quote. After etherization, a loop of intestine is withdrawn through an abdominal incision, a cannula tied into one end of it, and a small electric lamp in the other. The whole is then brought under the microscope and circulation of the wall of the gut studied under different pressures obtained by water introduced through the cannula. The degree of pressure was noted on a mercury manometer, placed in circuit with the pressure bulb. At a pressure of 30 mm. mercury it was found that some of the capillary streams were arrested. At 60 mm. many small veins had their current arrested, and in most of them the stream was so slow that individual corpuscles could be seen. At 90 mm. many of the blood-streams ceased motion entirely and the others were moving very slowly.

Currents were observed going in one direction at one time, the next moment in the opposite. At 130 mm. all circulation stopped.

Some ecchymotic hemorrhages were noted as early as 50 mm.

Gut kept at 80 to 90 mm. pressure for an hour became enormously congested. Small drops of fluid were observed standing upon the surface of the gut like beads of perspiration, illustrating the manner in which the formation of serous exudate takes place in strangulated hernia.

Van Zwalenburg believes that this experiment demonstrates the importance of distention as a factor in the production of strangulated hernia. In other words, it is added confirmation of Kocher's theory of dilatation.

It is probable that there is a certain amount of truth in each of the theories that have been described, but that no one of them is the sole factor in strangulation. The principal objection to Roser's theory is that in cases of actual strangulation in man no such valves as he describes have been found. The main objection to Lossen's theory of compression by solid feces is that it is an extremely rare occurrence to find solid feces in a strangulated loop, the latter being nearly always filled with gas or a small amount of liquid feces.

The simplest explanation of the mechanism of strangulation is that we have a narrow ring, not exactly like the rigid cardboard ring as used in the various experiments mentioned, but a ring more or less elastic; a loop of bowel, in the great majority of cases a loop of empty small intestine, is forced through this ring by some unusual increase in intra-abdominal pressure. As soon as this pressure subsides, the ring contracts to its normal size, producing marked constriction of this loop, in many cases sufficient to interfere with its venous circulation. The peristaltic action of the intestine above the constriction continues to force gas and possibly liquid feces through the partially obliterated lumen into the extruded loop, gradually distending it more and more. As this distention increases, the more serious becomes the interference with its circulation, and it is easy to understand how the angulation theory of Busch or the dilatation theory of Kocher may play their rôle; such a rôle, however, is always secondary.

Pathologic Anatomy.—First we have, as a result of the interference with the circulation, a venous stasis which is followed by the pouring out of serous exudate which soon fills the sac and may be so abundant as to obscure the tympanitic note of the bowel. The fluid, at first a clear amber in color, later becomes tinged with blood, and finally may become turbid from the presence of leukocytes. In the early stages the fluid is practically always sterile, but later on it contains bacteria which have found their way through the intestinal wall. The loop of bowel is at first of a much brighter red than normal, owing to its congestion; later on, it becomes of a purplish hue and, finally, with the approach of gangrene, turns to a grayish color, loses its smooth, glossy appearance, and the surface becomes granular. In gangrene the process begins in the mucous membrane and extends to the serous coat. Gangrene may occur at a comparatively early period, sometimes beginning six to seven hours after the appearance of the strangulation, dependent on the tightness of the constriction. If the constriction is sufficiently tight to cause arterial and venous stasis at the same time, gangrene takes place with great

rapidity, while with a larger ring the process may be much delayed, sometimes not beginning until two or three days after strangulation.

Clinical History and Symptomatology of Strangulated Hernia.—In most cases the clinical picture of strangulated hernia is so characteristic that the diagnosis is clear. With very rare exceptions strangulation occurs in persons who have had a hernia for a considerable period of time. In a few instances it has been found in individuals without any previous history of hernia. Personally, I have seen two such cases. In these cases we must believe that there was present a congenital, partial or complete funicular process of peritoneum, into which the hernia had suddenly been forced by some unusual abdominal effort. The first thing the patient notices is a sudden, sharp pain in the region of a hernial orifice, usually appearing immediately after some severe muscular effort, *e. g.*, lifting, coughing, sneezing. In the case of an old hernia that has hitherto been reducible the patient finds on examination a swelling somewhat larger than usual which can no longer be returned into the abdominal cavity. The tumor is at first moderately soft in consistence, but quickly becomes more and more tense and tender. The colicky pains continue with greater severity, owing to the increased peristalsis of the bowel above the point of constriction; soon nausea and vomiting appear. The interval of time elapsing before vomiting occurs depends much upon what portion of the intestine is strangulated. If the constriction occurs low down in the small intestine, vomiting may be considerably delayed; if high up in the ileum, it sets in very quickly. The vomitus at first consists merely of the ordinary stomach contents. If the constriction is not relieved, it soon contains bile, and later assumes a fecal character. There is complete constipation, and although a small amount of feces already present in the bowel below the constriction may be brought out by enemata, no real bowel movement takes place. The changes which rapidly occur in the imprisoned bowel are congestion and exudation, which give rise to corresponding changes in the physical signs. The tumor becomes not only more tense, but more tender on pressure, and if the strangulation is allowed to persist without relief, the sac and overlying tissues may all become edematous and infiltrated and gangrene of the gut may ensue. In rare cases the skin itself finally becomes involved, the gangrene of the bowel extending through the sac and overlying tissues, which become rapidly disintegrated by the action of the powerful bacterial toxins and, finally, an external opening or artificial anus is produced and nature thereby effects a cure. Such a result is, however, extremely rare, and in the great majority of cases, probably 98 per cent., the peritoneal inflammation extends within the ring, causing general peritonitis and death, before there has been time to produce an external opening.

General Symptoms.—The first symptom of strangulation is marked shock, as shown by a weak and rapid pulse, 110 to 150; the expression becomes anxious, the breathing rapid and shallow; the eyes are sunken, the lips cyanotic. The temperature may at first slightly rise, 99.5° to 100°, but later on, as the shock becomes more profound, temperature

and pulse fall to subnormal; still later, after gangrene has set in, the temperature again rises sharply, due to the absorption into the general circulation of the products of the gangrene. The urine is scanty or even suppressed and of a high color. If only a portion of the wall of the bowel is constricted (Richter's hernia) the same symptoms and physical signs are found, although ordinarily of a mild type.

Diagnosis of Strangulated Hernia.—Most errors in diagnosis have been due to lack of careful physical examination. The patient has had a small femoral hernia that has never given any trouble. The loop of bowel is so small that no very noticeable external tumor is present. Hence it may be easily overlooked by a careless examiner. The local symptoms may be obscured by the general symptoms. This is especially true of strangulated obturator hernia, in most of the recorded cases of which no diagnosis was made until an exploratory operation for intestinal obstruction revealed the true condition. There is another condition which I have several times seen mistaken for strangulated hernia, *i. e.*, hydrocele of the cord, in infants and young children. Here we have the added difficulty of not being able to obtain any personal history of value. The mother states that the swelling suddenly appeared in the inguinal region, although it may really have been present days before it was noticed. Physical examination reveals a condition that cannot easily be differentiated from strangulation. We have a tense sac, filled with fluid, occupying exactly the position of a strangulated hernia, and in many cases it appears to enter the canal, and whether or not it connects with the abdominal cavity is by no means easy to establish. How, then, are we to make the diagnosis? By a careful examination of the general condition of the patient. (1) Temperature, which will be found normal; (2) absence of shock; (3) absence of any symptoms of strangulation, *e. g.*, nausea and vomiting; (4) absence of constipation; careful questioning will disclose the fact that the bowels have remained regular. With such a history we can absolutely rule out strangulated hernia and make a diagnosis of hydrocele of the cord. I have seen many such cases treated by taxis for hours, sometimes with, sometimes without, an anesthetic, the diagnosis of strangulated hernia having been made solely on the physical signs of the tumor and the statement of the nurse or mother that the swelling had appeared suddenly.

Hydrocele in infants and young children is a perfectly harmless condition which does not require operation and usually disappears spontaneously or after the external application of tincture of iodin and belladonna for a few weeks.

The differentiation between obstructed, inflamed, and strangulated hernia may be made by the following signs:

Obstructed Hernia.	Inflamed Hernia.	Strangulated Hernia.
Impulse preserved.	Impulse preserved.	Loss of impulse.
Pain moderate.	Pain moderate and local.	Pain severe.
Tension and tenderness absent or trifling.	Tender but not tense.	Tension and tenderness.
Vomiting absent or not repeated.	Vomiting not pronounced.	Vomiting.
Constipation relieved by enemata.	Constipation not persistent.	Constipation.
		Shock, more or less pronounced.
		Pulse rapid and feeble.

Strangulated Omental Hernia.—If a portion of the omentum be forced into the sac under conditions similar to those described in strangulation of a loop of intestine, this will produce the same changes as those just described, *i. e.*, interference with the venous circulation; later with the arterial circulation; serous exudate of the sac, and finally gangrene. The symptoms closely resemble those found in strangulation of the intestine, though they are nearly always somewhat less severe. There is usually nausea and vomiting, local pain, but less colicky in character than in intestinal strangulation. The shock is much less, and while constipation may be present, it is seldom complete. The tumor is tender on pressure, quite dull on percussion, and in most cases the lobulated surface of the omentum can be made out by careful palpation.

Partial Enterocele.—This variety of hernia was first described by Fabricius Hildanus[10] in 1598, but received little attention until 1700, when Littré[11] published his well-known monograph on "Observation sur une nouvelle espèce de Hernie." Treves, in 1887, reported four cases with one recovery. Fowler,[12] in 1899, gave a careful review of the literature. Neither of Littré's original cases was probably a partial enterocele, but rather due to a diverticulum.

Partial enterocele was also carefully described by Richter in 1778, who, however, referred to small hernias between ensiform cartilage and umbilicus.

Scarpa, in 1809, showed that if two-thirds of the circumference of the bowel were constricted the entire lumen became shut off, while if only one-third was constricted the fluids could still pass.

Treves,[13] in 1887, collected sixty-three cases of partial enterocele, one-third of which showed symptoms similar to those found in strangulated hernia. In two-thirds the symptoms were of a less severe type. One-tenth of the cases showed a movement of the bowel on the first or second day. The majority of cases have been observed in females, and only in adults.

I have operated upon one case of partial enterocele in a boy fifteen years of age. In this case about two-thirds of the lumen of the bowel was constricted. The symptoms were practically the same as those found in strangulated hernia. The patient made a good recovery. There was no previous history of a hernia.

Usually the condition occurs in cases of old hernia; the tumor is always of small size, rarely larger than a hen's egg. The ileum is usually found in the sac.

The prognosis in these cases is bad, due chiefly to the late diagnosis: it is much worse than in ordinary strangulated hernia. Fifty per cent. of the cases reported by Treves were not operated upon and all died. The total mortality for the entire series was 62.2 per cent.

Treatment of Strangulated Hernia.—Strangulated hernia improperly treated is attended with a high mortality; properly treated, with comparatively little risk. Hence the importance of a correct understanding of the principles on which such treatment is based.

The principle first in importance, which should have a place before all others, is promptness. There are few conditions in which delay is attended with graver risks. The famous dictum of Stromeyer: "If called to a case of strangulated hernia in the daytime the sun should not be allowed to set, if called in the night the sun should not be allowed to rise, before the strangulation has been relieved," still deserves a place in every text-book. In our opinion, Stromeyer even does not go far enough. The physician or surgeon who has a case of strangulated hernia should perform no other duty before the strangulation has been relieved.

There are only two methods of treatment worthy of consideration: taxis and operation.

Taxis.—By taxis is meant the attempt to reduce the hernia by forcible manipulation. In performing taxis the position of the patient is of some importance. The hips should be elevated, thighs and legs flexed. If the hernia be on the right side, the upper portion of the neck of the hernia should be firmly grasped with the left hand, the fundus of the hernia with the right hand. Before attempting to force the hernia backward into the abdomen, an effort should be made, by traction, to draw out a little more of the bowel. After this has been done reduction may be attempted by alternate pressure over the neck and fundus of the sac. Various authorities give different limits of time during which it is safe to persist in taxis. These limits vary widely, between a few minutes and two hours. I do not think it wise to continue taxis more than five minutes. There are certain cases of strangulation in which it is absolutely dangerous to use taxis for any period of time. Such cases are (1) those in which the symptoms of strangulation have been exceedingly severe from the start, showing that the constriction is very firm, and, hence, there is reason to fear early gangrene. Here taxis is contraindicated for the reason that even moderate manipulation may cause perforation, followed by the escape of some of the infected fluid into the abdominal cavity and resulting in fatal peritonitis. If one is sure that the omentum alone is contained in the sac, taxis may be continued for a little longer than with an enterocele. Aspiration of the fluid contents of the sac, which is highly recommended by some, must be looked upon as a measure of doubtful value and not free from risk. (2) Cases in which strangulation has occurred in previously irreducible hernia, *e. g.*, in voluminous umbilical and scrotal hernias; and (3) in cases in which twenty-four hours have elapsed after strangulation. If the first efforts at taxis carried out in the way and at the time indicated prove unsuccessful, there are certain measures which may be looked upon as adjuvants or aids to taxis worthy of mention. Among these are: (1) Hot and cold applications. In the very young and the very old it is wiser to use hot applications in the way of hot towels, as hot as can be well borne and changed every two or three minutes; while in the strong and vigorous and middle-aged applications of ice may give better results than heat. After these applications have been used for half an hour, another attempt at taxis of very short duration may be made. If this again fails, preparation should be made for immediate operation. In a certain number of cases it may be possible to reduce the hernia under anesthesia, although taxis had failed before; but an anesthetic should never be given until all the preparations have been made for immediate operation, should taxis under anesthesia fail. In practically all cases I believe it wiser to perform a radical operation after the hernia has been reduced, the only exception to this rule being in the case of gangrenous hernia in which the condition of the patient does not warrant the brief delay necessary for carrying out the steps for radical operation.

If a hernia has been successfully and completely reduced by taxis, there is almost immediate cessation of the symptoms. The bowels move spontaneously within the first twenty-four hours, or may be moved by an enema. It is unwise to use laxatives very soon after reduction. The

patient should be kept in bed until all symptoms have disappeared and until the bowels have begun to move satisfactorily. To prevent a reappearance of the hernia, a pad should be placed over the opening and held by a firm spica bandage.

Dangers of Taxis.—The dangers of taxis may be summarized as rupture of the bowel or sac; severe contusions, with hemorrhage of the wall of the bowel; reduction *en bloc* or reduction into an internal portion of a bilocular sac.

Reduction of the Hernia en bloc.—In the latter case, while the hernial tumor disappears, there is persistence of the symptoms after reduction. As we have stated under "Pro-peritoneal Hernia," such cases are usually cases of bilocular, interparietal hernia, in which the hernia has been reduced into the inner sac instead of representing a true reduction *en masse.* In these cases immediate operation should be performed.

Operative Treatment.—The operation for strangulated hernia, usually known as kelotomy or herniotomy, consists in an incision over the inguinal canal and relieving the constriction, whether it be the external ring, or the neck of the sac, by cutting from within outward or vice versa. If operation is performed under modern aseptic conditions and within the first twelve hours, it is attended with very slight mortality, probably not over 3 to 5 per cent. It is much less dangerous than taxis injudiciously applied. If there are any contraindications to general anesthesia, it may be easily performed under local anesthesia.

Methods of Operation.—For inguinal hernia an incision 3 or more inches long should be made, beginning a little below the anterior superior spine and ending over the external ring. The older method of making an incision low down over the upper part of the scrotal tumor is not to be recommended. After clearly exposing the aponeurosis of the external oblique, particularly the region of the external ring, precisely as in the Bassini operation for radical cure, the external ring is opened on a grooved director; in some cases, especially where there has been extensive fibrinous exudate, the wall of the sac and the fibers of the external ring may be so closely agglutinated that it is difficult to insert a director without running the risk of injuring the bowel beneath. In such cases the fibers of the external oblique can be lifted up with two pairs of forceps without teeth and divided from without inward. The line of cleavage of the aponeurosis will quickly become apparent and the director can now be inserted and the aponeurosis slit up for a distance of 2 to 3 inches. In the great majority of cases dividing the external ring will sufficiently relieve the constriction to enable one to easily reduce the contents of the sac. This, however, should never be done until the sac has been opened, for the reason that the bowel should never be returned into the abdomen until it has been carefully examined in order to determine its viability. After opening the sac and emptying it of its fluid contents, the bowel, if its condition warrants, is returned into the abdominal cavity. Unless the condition of the patient is extremely precarious, the sac should be quickly removed and the hernial opening closed by the usual method of radical cure. I practically never employ

drainage except in cases in which there is marked thickening and inflammation of the sac and the surrounding tissues. In such instances it may be wise to insert a temporary drain down to the peritoneum. In cases in which there is doubt about the vitality of the bowel, towels wet in hot saline solution should be applied for a period of ten to fifteen minutes. If at the end of this time the purplish color has turned to bright red with the glossy appearance of the intestine still retained, it will be safe to replace the bowel into the abdominal cavity.

Strangulated Hernia in Infants.—Estor[14] collected 225 cases of strangulated hernia in children under the age of two years. The condition is a relatively rare one. Estor, after a search of the records of the children's hospitals connected with nine of the largest clinics of Europe, found not a single operation for strangulated hernia. Broca, of Paris, however, operated upon 9 cases in a total of 950 operations upon children.

At the Hospital for Ruptured and Crippled we have operated upon 17 cases in children, of which 12 were under the age of two years.

Estor estimates the relative frequency of strangulation in children and adults as 1 to 62; Frickhoffer, as 1 to 107. Estor's collected cases (225) showed 205 inguinal (male), 14 umbilical, 2 femoral; 120, or over one-half of the total number, occurring within the first six months of life. Of the 14 umbilical, 9 occurred within the first week. In 10 cases no hernia had been noticed up to the time of strangulation.

Estor, with most other writers, believes the neck of the sac to be the cause of the strangulation in the majority of cases, but furnishes no proof.

At the Hospital for Ruptured and Crippled a careful study was made in every case of the cause of strangulation, and in but a single case was it found due to the neck of the sac; in all other cases it was caused by the tight external ring.

According to Estor's observation the cecum and appendix were found relatively more often to form the contents of the sac in strangulated hernia in children than in adults. The appendix or cecum and appendix were found in the sac in 17 of the 225 cases.

The mortality in children I believe to be considerably smaller than in adults, although the mortality of Estor's series was 23 per cent., which is practically the same as the mortality in adults. At the Hospital for Ruptured and Crippled there has been no mortality in the seventeen cases operated upon.

Prognosis.—This depends upon the duration of the strangulation, the tightness of the constriction, and the general resisting power of the patient. As a rule, the mortality increases in direct ratio with the time of strangulation. The younger the subject and the smaller the volume of the hernia, the better the prognosis. The prognosis is most unfavorable in the voluminous scrotal and the large umbilical hernias, for the reason that in these cases there is nearly always present a large mass of irreducible omentum with extensive adhesions. In such cases it may sometimes be wiser simply to relieve the constriction, and reduce the sac and intestine together into the abdominal cavity, without attempting to separate the numerous and firm adhesions. This plan should only be adopted in very rare cases and in patients whose general condition does not warrant prolonged operation.

Complications.—Complications in strangulated hernia are nearly always the result of injudicious taxis. Too forcible or too prolonged taxis may result in hemorrhages into the bowel wall, or in cases in which the vitality of the bowel has been impaired, it may result in perforation, practically always followed by either local or general peritonitis. In some cases in which taxis has been apparently successful, symptoms of intestinal

obstruction may develop after a few days, resulting from the adhesions between the strangulated loop and some neighboring coil of intestine. These symptoms may increase in severity, requiring a second operation. Intestinal obstruction from adhesions is much more likely, however, to follow operative treatment than taxis, in cases in which a portion of the intestine was reduced which it would have been wiser to remove by resection.

Paralysis of the intestine sometimes follows reduction either by operation or taxis. This paralysis is due to the long constriction of the bowel. The condition is not serious, and seldom requires surgical treatment. After a short period the paralysis disappears and the intestine begins to perform its normal function. Symptoms of intestinal obstruction, however, are most serious, and should be treated by abdominal section.

One of the serious risks from operation for strangulated hernia is inhalation pneumonia, occurring as a result of some of the fecal contents of the stomach having been drawn into the larynx by inspiration during the anesthesia. This risk can nearly always be avoided by washing out the stomach before operation for strangulated hernia.

Mortality Following Operative Treatment.—The mortality following operation for strangulated hernia varies from 10 per cent. in the cases operated upon within the first twenty-four hours after strangulation, to 50 per cent. in those cases in which the strangulation has existed for a period of seventy-two hours. The mortality is lowest in children and highest in elderly people. At the Hospital for Ruptured and Crippled we have had seventeen operations for strangulated hernia in children, with no mortality. The death-rate is higher in femoral than in inguinal hernia, and highest of all in umbilical hernia. Most of the statistics show a mortality of upward of 50 per cent. in strangulated umbilical hernia.

The mortality in gangrenous hernia should receive separate consideration, as the condition is a much more serious one.

Treatment of Gangrenous Hernia.—If the intestine has lost its glossy appearance and the surface has become dull and granular, its color black or grayish, and it is soft and flabby instead of firm and elastic in character, the probabilities are that it is no longer viable. In all cases of doubt it is well to apply compresses wrung out of hot saline for ten to fifteen minutes. If at the end of this time there are no signs of a return of circulation, there is no need of further delay. The pulsation of the vessels of the mesentery and bowel is, in the opinion of Kocher, one of the most valuable signs of viability. If the loop is clearly gangrenous when first exposed, no time should be lost by applying compresses, but operation should be performed at once. There are a certain number of borderland cases, however, which may puzzle the most experienced surgeon, and such cases require the exercise of the greatest judgment. In these dubious cases the loop of bowel may be allowed to remain *in situ* for twelve to twenty-four hours, carefully protected with sterile gauze. If at the end of this time it has sufficiently recovered its circulation, it may be replaced in the abdominal cavity; if not, prompt resection should then be performed.

I shall now consider the cases in which the loop of bowel is absolutely gangrenous. There are two methods of procedure that have long been employed in these cases: namely, the formation of an artificial anus, and immediate primary resection of the gangrenous loop. Both methods have had strong advocates, and even at the present time there is by no means unanimity of opinion as to which is the better method. It is difficult to prove the superiority of either procedure by statistics. Practically all statistics show a much higher mortality in the cases treated by the establishment of an artificial anus. Yet it has long been the custom to reserve only the more desperate cases for this method of treatment and, hence, a comparison of actual results is by no means fair. In spite of this fact, more recent statistics, based upon a large number of cases operated upon by the same surgeon or at the same clinic, presumably under the same general technic, show, in our opinion, that primary resection should be the method of choice in the great majority of cases. The choice of method, however, cannot be decided solely by statistics, as there are a number of important factors which must be considered, *e. g.*, the general condition of the patient, the surgical skill and experience of the operator, together with the facilities for performing such a serious operation as intestinal resection. Given a patient in fairly good general condition and a surgeon with some experience in abdominal operations, the choice should be unhesitatingly in favor of primary resection. On the other hand, with a patient much prostrated, with a large portion of intestine gangrenous, necessitating very extensive resection, in spite of the high mortality attending the operation of establishing an artificial anus I believe the chances of recovery of such patient would be better than if immediate resection were performed. Of course, when forming an artificial anus one has to consider the fact that although the patient recovers from the immediate operation, he is left in a condition which will in most cases require a second operation, which is likewise attended with considerable risk. While in some cases an artificial anus may close spontaneously, in most instances a secondary operation is required. If the artificial anus is high up in the small intestine the nutrition of the patient will be so seriously affected that a secondary operation cannot be long delayed.

The spur that is usually formed in cases of artificial anus may, in some cases, be removed or gotten rid of by some form of clamp. In view of the difficulties and dangers of such methods, resection is preferable.

If an *artificial anus* is decided on, it should be performed as follows: After the constriction has been thoroughly freed, the bowel is drawn out until well beyond the line of constriction. It is then fastened in place to the parietal peritoneum beyond the neck of the sac, as high up as possible, by interrupted Lembert sutures of fine silk or catgut. After the wound has been carefully packed with sterile gauze, protecting as far as possible the peritoneal cavity, the bowel is opened and a tube is inserted into the afferent end and the gas and fecal matter removed as far as possible by saline irrigation. The loop of bowel should then be covered with a large amount of moist sterile gauze. While it is impossible

to keep the wound aseptic, one should aim to keep the parts as clean as possible by frequent change of dressing. The patients usually die of exhaustion or peritonitis within a few days. The skin about the wound should be carefully covered with vaselin or boric acid ointment in order to prevent the development of eczema, which is very prone to occur under such conditions.

In the cases which recover without a secondary operation the gangrenous loop sloughs off, the artificial anus, through which at first the entire contents of the bowel are discharged, gradually contracts, until it becomes a fecal fistula through which only a small portion of the feces passes, until finally this fistula itself closes.

Such are the exceptional cases. In the majority of cases a secondary operation must be performed, consisting of resection of the damaged portion of the gut, with end-to-end anastomosis.

Primary Resection.—The weight of opinion is at present in favor of primary resection, with the important exceptions which have already been noted, and in this opinion I fully concur.

Method of Operation.—Most surgeons prefer the suture operation, but a number believe, with Czerny and Petersen, that the best results are obtained by the use of the Murphy button. Petersen employed this method at the Heidelberg Clinic, and in twelve cases in which he used the button there was only one death, or a mortality of 8 per cent. No such results have been obtained by any other method.

The collective statistics of the following authors as given by Hesse,[15] show the respective mortality of resection and artificial anus in cases of gangrenous hernia:

	Artificial Anus.			Resection.		
	Cases.	Died.	Per-centage.	Cases.	Died.	Per-centage.
v. Mikulicz.....1891	94	72	76.6	68	32	47.1
Zeidler.....1892	287	213	74.2	289	142	49.1
Butz.....1892	204	104	50.9	219	101	46.1
Akerman.....1899	70	55	78.6	112	45	40.1
Hofmeister.....1900	167	101	60.5	214	99	46.3
Hesse.....1907	604	431	71.3	860	382	44.3

Lessing's statistics,[16] covering 156 operations for incarcerated hernia, performed at Koenig's Clinic (Berlin) from March, 1896, to March, 1903, with a mortality of 17.3 per cent., show 35 cases of gangrenous hernia with 13 deaths, or a mortality of 37.1 per cent.

As regards the treatment of the gangrenous cases, it is stated that radical closure of the hernial opening could be performed in one-third of the cases; resection was done in 9, and in 9 others an artificial anus was established.

Torsion of the Omentum.—This condition is comparatively rare. Pretsch[17] was able to collect but 15 cases in addition to the 29 which form the basis of Roche's Paris thesis.[18] Forty-two of these 44 cases were

complicated with hernia, 41 inguinal and 1 femoral. All the cases occurred in adults between seventeen and seventy-nine years; 66 per cent. were between thirty and fifty years of age.

Seventy-four per cent. of the cases were observed in men, 24 per cent. in women.

The diagnosis is not often possible, as the clinical picture closely resembles incarceration of the omentum, volvulus, or torsion of other abdominal organs; intussusception and new-growths must also be considered in making the differential diagnosis. In none of the published cases was the diagnosis made before operation, although Pretsch believes the following points should be of diagnostic value: (1) Determination of a cause of the trouble, from the history; (2) the presence of a hernia, possibly irreducible; (3) the rapid development of a large, hard, freely movable tumor with numerous tuberosities; (4) the finding of a cord-like connection between a hernial and abdominal tumor.

The prognosis depends upon early operation. Six deaths, or 14 per cent., were noted in the series thus far reported. One of the cases died before operation; in another operation was performed too late, and in two others death was evidently due to other diseases complicating the condition.

Riedel[19] in the same year published 6 further personal observations, and Adler[20] was able to collect from the literature 52 cases of torsion of the omentum, to which number he adds one personal case, which he describes at some length.

Torsion of the Cord.—This is a very rare condition, but inasmuch as it is nearly always associated with hernia, should be mentioned in this connection. Sasse[21] has made a careful study of this subject and has published a case which, he states, is the nineteenth on record. According to Corner,[21a] the following clinical picture obtains in the majority of cases: A swelling occupying the inguinal region, recurring attacks of pain, absence of impulse on coughing. This picture, while it resembles that of strangulated hernia, may be differentiated from same by the fact that the swelling is more irregular, more tender, and harder, while the general symptoms of strangulation are absent.

The diagnosis is seldom made before operation, nearly all the cases having been mistaken for incarcerated hernia. The symptoms during the first few days closely simulate those of incarcerated hernia. If torsion has existed for twenty-two hours, according to Enderlen, the interruption of circulation is sufficient to produce atrophy of the testicle. In nearly all the reported cases the testicle was removed. This is believed to be the safest procedure. I have personally seen one case, and in this the diagnosis was made from the clinical history and careful physical examination.

Tuberculous Hernia.—Tuberculosis of the hernial sac may be found either as a primary condition, or as secondary to tuberculosis in other portions of the peritoneum. Tenderich[22] collected 19 cases of tuberculosis of the hernial sac, reported in the literature, to which he added three further cases observed at Helferich's Clinic, giving a total of 22 cases. Two of Helferich's cases occurred in children, one three, the other eight years of age. Unfortunately, the results of the cases thus

far operated upon have not been traced. One of Helferich's cases remained well for two years, then contracted influenza which resulted in pulmonary tuberculosis, causing death six months later. The other two cases were traced only seven months.

Personally I have observed three cases of tuberculosis of the hernial sac; one, a femoral hernia occurring in an adult female. The patient was not traced beyond six months. The other two cases occurred in children at the Hospital for Ruptured and Crippled, one was operated upon by myself, the other by Bull. The ages of these cases were twenty-eight, eight, and six years, respectively. In all of these cases the condition was very similar; the sac was considerably thickened and studded with small tubercles which microscopically proved to be tubercle bacilli.

Tenderich's collection of 22 cases shows 14 inguinal hernias, 4 femoral, and in 4 the type is not stated.

Special Hernias.

Inguinal Hernia.

This term refers to all hernias having an outlet through the inguinal canal. These hernias are subdivided into: (1) Direct or internal inguinal hernia. (2) Indirect or oblique inguinal hernia.

Oblique inguinal hernia may be either congenital or acquired, while direct hernia is probably in most cases acquired. The distinction between congenital and acquired hernia has already been sufficiently dealt with under General Remarks (p. 18).

Fig. 22.—Oblique Inguinal Hernia. Complete.

Oblique Inguinal Hernia.—This is the most common of all varieties of hernia, 93 per cent. of all inguinal hernias being oblique.

Anatomic Relations.—In oblique inguinal hernia the sac emerges from the abdomen through the internal ring above and a little outside of the deep epigastric artery; it then passes downward in an oblique direction, parallel with Poupart's ligament, crossing almost at right angles the deep epigastric vessels, finally emerging at the external ring. In the early stages of oblique inguinal hernia, before the protrusion has passed beyond the external ring, the hernia is known as an incomplete hernia or bubonocele. A hernia which has passed beyond the external ring and entered the scrotum is known as a complete or scrotal hernia in the male; in the female a hernia which has passed beyond the external ring and entered the labia major is known

as a complete or labial hernia. There is a much greater tendency for an oblique hernia in the male to become scrotal than for one in the female to become labial. In the female oblique inguinal hernia has a greater tendency to enlarge directly outward in globular form, resembling direct hernia, than it has to enter the labia.

Fig. 23.—Left Inguinal Hernia.

In the normal inguinal canal the external ring barely admits the tip of the index-finger and one cannot palpate the internal ring. In a large hernia of long duration the inguinal canal may become not only dilated, but so shortened as to almost entirely lose its original obliquity. Hence, in such cases it may be difficult to differentiate a direct from an indirect hernia, except at operation.

The anatomy of oblique inguinal hernia may be briefly described as follows: At the internal ring, situated about half-way between the anterior superior spine and the symphysis pubis, about half an inch internal to Poupart's ligament emerges the hernial sac. It passes downward and inward to beyond the external ring. This sac rests upon a floor formed by the transversalis fascia and the peritoneum, between which layers lie the deep epigastric vessels. The roof of the canal is made up of the internal and external oblique muscles, the aponeurosis of the external oblique, the cremaster muscle, superficial fascia, subcutaneous tissue, and skin. The external ring is formed by the arched fibers of the aponeurosis of the external oblique, and varies in size according to the size of the hernia itself.

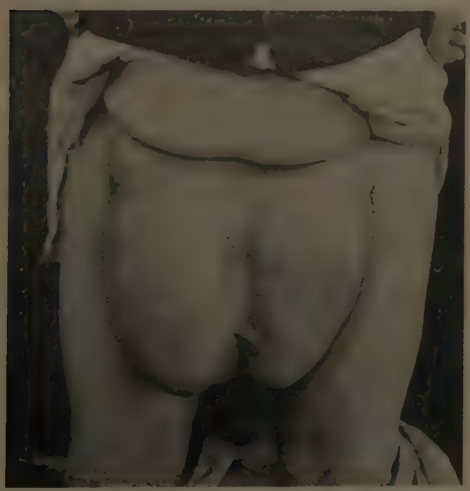

Fig. 24.—Double Inguinal Hernia. Inoperable.

FIG. 25.—LABIAL HERNIA.

Relation of the Sac to the Cord.—As the sac passes in its downward course, it always occupies a certain definite relationship to the cord. In oblique inguinal hernia it lies directly in front of and in intimate contact with the cord, the two being surrounded by a common layer of thin fascia, known as the infundibuliform fascia. The cord consists not of a definite, rounded body, but its vessels are spread out in a fan-like manner over the posterior surface of the sac, sometimes occupying space of an inch or more.

In direct hernia, on the other hand, this intimate relationship between cord and sac does not exist, the cord is this variety of hernia being quite independent of the sac.

The shape of an oblique inguinal hernia depends entirely upon whether it is complete or incomplete. In a bubonocele the tumor over the inguinal canal is usually elliptic in shape and is seldom very pronounced except on standing or coughing.

A scrotal hernia may assume a great variety of shapes. In a hernia of small size it is usually cylindrical; in a very large hernia it may be pear-shaped, the lower end being the larger. In very large hernias the penis may be entirely obliterated.

Inguinal Hernia in the Female.—Inguinal hernia in the female forms 60 per cent. of all ruptures in women and exceeds the total number of femoral hernias in both sexes. The diagnosis is seldom diffi-

FIG. 26.—LABIAL HERNIA.

cult. While in a very small number of cases the hernial tumor extends into the labium, it is usually found in the inguinal canal or just outside of the external ring. The tumor disappears on lying down, except in a comparatively few cases in which the contents are irreducible. A truss seldom effects a cure, even in children, and, inasmuch as the results of operation are more nearly perfect in this than in any other variety of hernia, operation should be advised in practically all cases, except in infants and the very old.

FIG. 27.—INGUINAL HERNIA IN FEMALE. SAC UNOPENED.

Methods of Operation. — Surgical opinions differ widely as to the best method of operation for inguinal hernia in the female. Championnière[23] was the first to point out the advantages of operation in this variety of hernia. In 1892 he reported 19 cases. His method was to excise the round ligament, slit up the aponeurosis of the external oblique, remove the sac high up, and then close the wound by his own overlapping method, just as in the male. Kelley advised transplanting the round ligament, as the cord is transplanted in Halsted's operation. He does not regard the removal of the sac, if small, as of much importance.

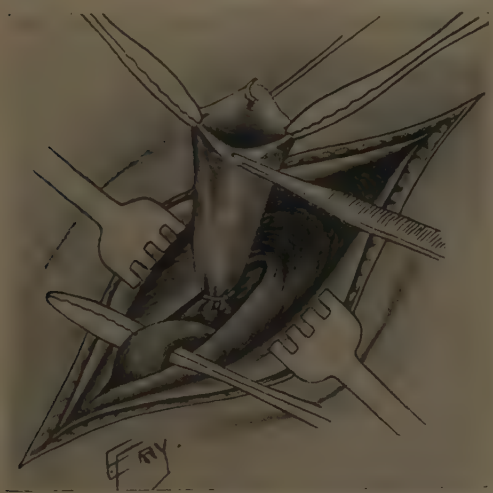

FIG. 28.—INGUINAL HERNIA IN THE FEMALE, SHOWING SAC DISSECTED FROM ROUND LIGAMENT.

In view of what has already been said in regard to the importance of the sac, even if of small size, as an etiologic factor in hernia, one must

consider its complete removal of primary importance in any operation for the radical cure of hernia. As to the method of dealing with the round ligament, there is no doubt that it can be removed with little harm to the patient, and possibly such removal might slightly increase the chances of a permanent cure. On the other hand, practically perfect results may be obtained without sacrificing the round ligament or transplanting it, as the results of operation at the Hospital for Ruptured and Crippled as well as my own fully prove. In the December, 1900, "Annals of Surgery" I reported 123 cases of inguinal hernia in the female operated upon during the preceding decade, without a single relapse. At the Hospital for Ruptured and Crippled 400 cases have been operated upon from 1890 to 1908, with two relapses, and my own cases, 350 in number, show only two relapses.

The method employed has been the same in all cases, namely, Bassini's operation for the male, without the transplantation step. In brief, the aponeurosis of the external oblique is slit up, just as in the male, well above the internal ring; the sac, which always lies anteriorly and closely adherent to the round ligament, is then carefully dissected off and removed high up, flush with the peritoneal cavity. The round ligament is allowed to drop back into the lower angle of the wound and the wound is closed in three layers, kangaroo tendon being used for the buried sutures. In the first layer the internal oblique is united with Poupart's ligament by four or five interrupted sutures; the lowermost suture should include the reflected portion of the aponeurosis of the external oblique as well as the conjoined tendon. The next layer closes the incision in the aponeurosis by means of a continuous suture of kangaroo tendon of smaller size. Finally the skin is closed with interrupted sutures of fine catgut, without drainage.

One of the most frequent sources of error in the diagnosis of inguinal hernia in the female is the presence of a *hydrocele of the canal of Nuck*. This condition is often, however, associated with inguinal hernia, and the same operative treatment is indicated in both conditions. In hydrocele of the canal of Nuck there is a tumor to be found just outside of the external ring, which is dull on percussion, globular in shape, symmetric in outline, tense and elastic, irreducible, and usually much more tender on pressure than a hernia. The history will usually reveal the fact that the swelling was at no time reducible.

The condition is by no means so rare as one might suppose from the literature on the subject. Wechselmann[24] found only 62 reported cases. In the "Annals of Surgery," in July, 1892, I published 14 cases observed at the Hospital for Ruptured and Crippled, and since 1890 160 cases have been observed at this hospital.

Direct Hernia.—Etiology.—While it is possible that in certain rare cases direct hernia may be due to a congenital or preformed sac, I do not go so far as Russell in believing this to be the common cause. In the great majority of cases I think direct hernia is due to a defective development of the internal oblique, or more often to a weak place in the transversalis fascia in the neighborhood of the external ring. This

variety is really a ventral hernia appearing in the lower inguinal region. Anatomically, the opening through which the hernia emerges is below and internal to the epigastric artery. It is bounded above by the epigastric artery, on the inner side by the internal oblique or transversalis fascia, on the lower side by the pubic bone, on the outer side by Poupart's ligament.

Diagnosis.—This type of hernia is usually found only in adult life and in adult males. There have been a few cases observed in children. Chas. N. Dowd[25] has operated upon one such case, a boy four years of age, at St. Mary's Hospital, New York. In upward of 2200 operations in children, at the Hospital for Ruptured and Crippled, not a single case of direct hernia in a child has been observed. While direct hernia is occasionally found in women, it is by no means so frequent as some authors have recently attempted to prove, *e. g.*, Escher,[26] who maintains that this type of hernia is more common in inguinal hernia in the female than in the male. But I believe that there are no statistics to uphold this view. Brenner[15] gives a very complete report of 1188 cases of hernia operated upon at the Linz Clinic, 1080 being men, with 95, or 9 per cent., of direct hernia in the male; and 108 women, with 2 cases of direct hernia, or 2 per cent., in the female. My own statistics show only 44 cases of direct hernia in 1980 operations, or about 2 per cent. Of these, 930 were in adults. Excluding the femoral hernias, 144 in number, there remain 786 inguinal hernias. Of these, 635 were males with 42 direct hernias; and 146 females with 2 direct hernias.

There is usually a history of slower development in direct, than in oblique hernia. The hernia never descends into the scrotum. A history of a definite, exciting cause, such as lifting or straining, is less frequently noted than in oblique hernia.

Physical examination shows several distinctive features. The shape of the tumor and its location are usually sufficiently characteristic for a diagnosis. The tumor is smooth in outline, globular in shape, and situated at the external ring; it is easily reduced by pressure and disappears spontaneously upon lying down. The tumor has no tendency to enter the scrotum, not even after long duration and on having attained large size. Examination of the canal reveals a circular opening which seems to pass directly backward into the abdominal cavity, instead of obliquely upward as in oblique inguinal hernia. Sometimes the deep epigastric artery, which should always be external to the opening, may be felt, but as it can be but rarely made out, this is a sign of little practical value, except in the cases that come to operation. There is one important clinical method which will nearly always enable one to make a positive diagnosis: After the hernia has been reduced, press two or three fingers over the internal ring, leaving the external ring free or uncovered. The patient is then asked to cough, and if the hernia is direct, it will emerge from the external ring; if it is oblique, the pressure over the internal ring will prevent its appearance. In some cases the diagnosis is very difficult, except by operation, as the following case (Fig. 29) well illustrates:

The patient, a boy of thirteen years, was admitted to the Hospital for Ruptured and Crippled in February, 1907, with a double inguinal hernia of nearly eight years'

duration. The hernial tumors had the typical globular appearance of a direct hernia, and although they had existed for a long time, they showed no tendency to enter the scrotum. Pressure upon the internal ring did not absolutely control the hernia on coughing. Operation, however, showed two typical oblique hernial sacs coming out of the internal ring above the epigastric artery, and emerging through the external ring.

Treatment.—As mechanical treatment offers no prospect of a permanent cure and generally fails to control the hernia, such treatment is usually unsatisfactory. Operation should be advised in all cases in which there are no contraindications. The Bassini operation should be the method of choice. The results are less satisfactory than in the oblique variety, but the majority, about 85 per cent., may be cured.

Interparietal Hernia (Properitoneal; Interstitial).—(1) **Properitoneal Hernia.**—In this form of hernia the sac is usually bilocular, the inner loculus lying between the peritoneum and transversalis fascia, and the outer in the inguinal or, more rarely, in the crural canal. In a few cases the outer loculus is found between the layers of the abdominal wall. In all cases there is a common orifice connecting both sacs with the abdominal cavity. The interstitial variety of hernia, often confused with the properitoneal, is also a bilocular hernia in which the upper sac lies beneath the external oblique and the skin. This type of hernia is known as inguino-superficial hernia. I agree with Moynihan[27] in believing that all these varieties, including properitoneal and interstitial, might, with propriety, be grouped under one general class of bilocular hernia, or perhaps with interparietal. Properitoneal hernia is comparatively rare. The first cases were described by Parise[28] in 1851, but we are indebted to the classic paper of Krönlein,[29] published in 1880, for the first comprehensive discussion of the subject. Krönlein collected twenty-three cases with full reports.

FIG. 29.—DOUBLE OBLIQUE INGUINAL HERNIA IN BOY AGED THIRTEEN YEARS SIMULATING DIRECT HERNIA.

Etiology.—Properitoneal hernia occurs almost invariably in the male and is in nearly all cases associated with malformation or incomplete development of the testis. A few cases, however, have been observed in the female, the first one reported being that of Bull and Coley;[30] two others have been observed by the writer. The causation of properitoneal hernia has been explained in a great variety of ways. In a certain number of cases I believe that the hernia is originally of monolocular type, the primary sac being in the inguinal canal or upper scrotum. In these

cases the testicle, situated in the canal or at the external ring, may act as a barrier against the further descent of the hernia, and, following the line of least resistance, the hernial sac enlarges upward between internal and external oblique aponeurosis, or possibly between the superficial fascia and aponeurosis, forming a hernia of the superficial type. If this explanation be correct, the presence of a hydrocele in the canal of Nuck in inguinal hernia in the female should act in the same manner, producing an interparietal hernia. One such example I have personally observed.

FIG. 30.—DOUBLE UNDESCENDED TESTIS WITH DOUBLE PROPERITONEAL HERNIA.
Right side hernia descending into perineum.

A number of theories have been offered in explanation of the development of bilocular hernias, but to my mind the most rational way of explaining their origin is to regard them as developmental errors, or diverticula of prenatal origin.

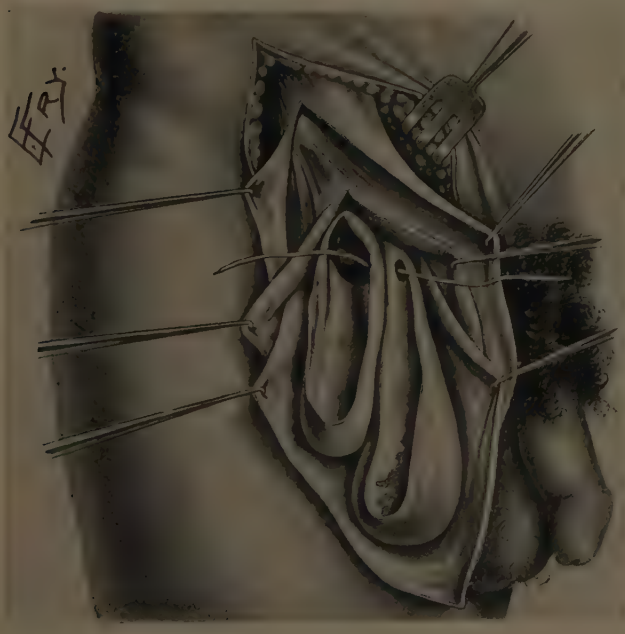

FIG. 31.—BILOCULAR SAC (Berger).

This theory, which represents also Moynihan's views, is further strengthened by a recent very valuable contribution of Cohn,[31] in his "Clinical Studies Regarding the Vaginal Process of Peritoneum."[41]

Cohn concludes that the percentage of congenital interparietal inguinal hernia is much larger than appears from the statistics hitherto published. He states that the only way of determining whether a sac is congenital or acquired is by micro-

scopic examination, and holds that only such cases of interparietal hernia can be regarded as really acquired as do not show smooth muscle-fibers in the wall of the hernial sac. Sachs expressed a similar opinion twenty years ago, stating that there are no gross anatomic signs to differentiate an acquired oblique inguinal hernia from a congenital, the smooth musculature of the internal cremaster being the only element of the cord which preserves a uniform relation to the vaginal process. In other words, if microscopic examination shows no regularly arranged smooth muscle-fibers in close proximity to the wall of the hernial sac, such sac is probably not of congenital origin. Cohn believes that interparietal sacs of inguinal hernia may be preformed and may attain to the average size without the coöperation of any mechanical factors. He states that, so far, not a single case of undoubtedly acquired inguinal superficial hernia has been reported. He further states that in superficial as well as in other interparietal inguinal hernias, the testicle may be in a normal position.

This is not, however, in accord with my own experience. I have personally observed 30 cases of inguino-superficial hernia, and in not a single case was the testis found in the normal position, but has either been in the inguinal canal or, in the majority of cases, in the distal portion of the sac, resting upon the external oblique, just beneath the skin and superficial fascia. Cohn states that a bilocular interparietal inguinal hernia may become monolocular in consequence of an obliteration of the vaginal process, provided that the descent of the testicle into the scrotum becomes complete before obliteration of the vaginal process above the testicle takes place.

Fig. 32.—Rare Type of Undescended Testis with Hernial Sac Extending to Bottom of Scrotum. Testis Arrested at External Ring.

Symptoms. — Symptoms have seldom been observed until the hernia had become strangulated, when the usual signs of acute or subacute strangulation appear. Even then there may be no physical signs sufficiently prominent to be detected by an ordinary examination. There is usually a history of an old hernia which has been treated by truss for a longer or shorter period. In certain cases an elliptic swelling may be made out in the upper inguinal or lower iliac regions. Breiter's collection of cases shows tumefaction in 22 out of 36 cases.

Moynihan believes this proportion to be in excess of the facts. Strangulation may be due to the internal or common neck of the sacs, the ostium abdominale, or to the neck of one of the two loculi; or, again, it may be due to a constriction of strong fibers of the external ring. This was the cause in a case personally observed by the writer. The symptoms are usually less acute than in the ordinary strangulated hernias; hence,

PLATE I.

Strangulated Properitoneal and Omental Hernia with Bilocular Sac.

the delay in advising operation which is usually observed in these cases. Properitoneal hernia is often mistaken for reduction *en masse*, and it is almost certain that many cases reported under this heading have been, in reality, examples of properitoneal hernia. Properitoneal femoral hernia is exceedingly rare, Breiter having been able to collect only nine cases: four left, three right, two doubtful.

Diagnosis.—The diagnosis of properitoneal hernia has seldom been made before operation. Given a small inguinal hernia, associated with undescended testis, and in addition a tumor in the iliac fossa, one should suspect the existence of a properitoneal hernia.

Treatment.—All cases of biocular hernia, even if the diagnosis is merely suspected, should be treated by operation.

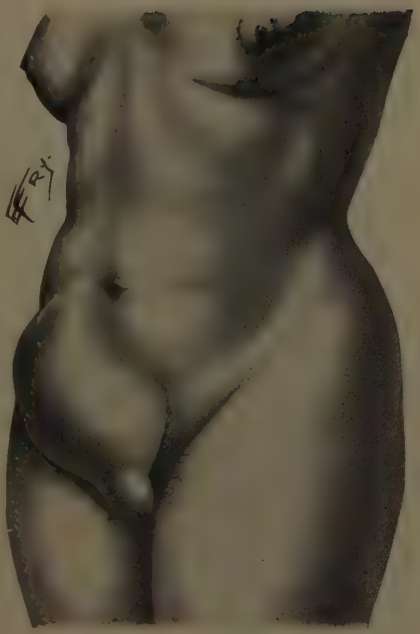

FIG. 33.—INTERSTITIAL HERNIA IN THE FEMALE, ASSOCIATED WITH HYDROCELE OF THE CANAL OF NUCK.

Interstitial Hernia.—Here the outer sac may be really secondary, and, owing to its more external location, may be more readily discovered than the properitoneal sac proper. It is practically always associated with some type of undescended testis, except in the very rare cases of interstitial hernia in the female. Three such cases have been personally observed by the writer. In one of these (see Fig. 33) there was a large hydrocele of the canal of Nuck, which was probably the causative factor in the development of the upper sac, the hydrocele tumor preventing the progress of the hernia downward into the labia, causing it to enlarge upward beneath the external oblique.

FIG. 34.—INTERSTITIAL HERNIA.

In by far the larger proportion of cases of interstitial hernia the sac lies underneath the aponeurosis of the external oblique, between the latter and the internal oblique. In some cases, however, the sac lies superficial to the aponeurosis, often extending up nearly to the anterior superior spine, covered only by the skin and superficial fascia. This variety of hernia is known as **inguino-superficial,** and has been described by Macready and Küster. Küster was able to collect only 14 cases, and, more recently, Moschcowitz[32] found only 17 cases in literature. The reasons why this variety has not been more frequently diagnosticated are (1) that it occurs far more frequently in children; (2) the diagnosis is seldom made after operation; (3) it is always associated with undescended testis; (4) the operation for undescended testis has not until recently been undertaken on a large scale.

FIG. 35.—INGUINO-SUPERFICIAL HERNIA.

In this variety of interstitial hernia the sac, after emerging from the external ring, extends upward, resting upon the aponeurosis of the external oblique, lying between the latter and the superficial fascia. It is practically always associated with undescended or maldescended testis and is not nearly so rare as is generally believed. In proof of the comparative frequency of inguino-superficial hernia, it may be stated that it was found in no less than 26 cases out of a total of 123 cases of undescended testis associated with hernia in which operation for the radical cure was done at the Hospital for Ruptured and Crippled. I have operated upon ten additional cases in adults. The accompanying cuts (Figs. 35, 36) show very clearly the position of the sac.

FIG. 36.—INGUINO-SUPERFICIAL HERNIA.

Etiology.—Macready[4] states that "when the sac ascends upon the external oblique a gap is usually, if not always, present in that muscle, so that the external and internal rings coincide, it is as if the anterior

abdominal wall were absent. As the hernia cannot descend upon the thigh on account of the attachment of the abdominal fascia to Poupart's ligament, it must ascend in the line of least resistance."

This explanation I believe to be incorrect, based, as it was at that time, upon a very small number of reported cases, and most of these lacking in accurate anatomic description. Furthermore, few, if any, cases in children had then been reported, and it is these cases in early life that naturally offer the best opportunities for a study in etiology. Our own cases have failed to show a single gap in the external oblique, and instead we have found a perfectly normal inguinal canal; but the sac, instead of entering the scrotum, is turned abruptly upward and outward 2 to 3 inches, until, in some cases, it nearly reaches the anterior superior spine. Most of the children were between six and ten years of age, and in many cases the hernia had been noticed since a few weeks after birth and no truss had been worn. Hence, it is difficult to accept the explanation based on the theory of the sac's having followed the line of least resistance in assuming its unusual position. There is another explanation which, in my judgment, is much more satisfactory and more in accord with our present knowledge of the etiology of hernia in general, namely, that by reason of some congenital developmental defect a diverticulum of peritoneum is present at birth in the region where the sac is found, although the hernia may not appear until long after. Just why such a diverticulum should assume this position, is difficult to say, but no more difficult than to explain why a congenital sac due to a diverticulum of peritoneum is found in femoral hernia.

After a little experience one can usually make the diagnosis before operation by the superficial position of the testis, which can, in most cases, be forced out by coughing. I have recently observed one case with the testis in the scrotum.

A word of caution is needed in making the skin incision when operating upon this variety of hernia. Great care should be exercised, inasmuch as the sac lies directly beneath the skin and superficial fascia and could easily be laid open and the testis and other contents injured by too bold an incision.

The *treatment* is the same as the treatment for hernia associated with undescended testis. The sac and testis are at first dissected free without opening the sac. The aponeurosis of the external oblique is then slit up as in the ordinary Bassini operation; the sac is next separated from the cord very high up; it is then cut across in the upper portion and sutured or tied off flush with the peritoneal cavity. The lower portion of the sac may be closed by a purse-string suture over the testis, thus forming a complete tunica vaginalis. The testis is then transplanted into a pouch made into the scrotum by means of the index-finger. The cord is usually sufficiently long to permit the testis to reach the bottom of the scrotum. The cord is not transplanted either in this or any other variety of hernia associated with undescended testis.

Inguino-perineal Hernia.—This is a rare variety of hernia, usually associated with mal-descent of the testis, the latter occupying the perineum instead of the scrotum. These cases are all undoubtedly of congenital origin, although it is by no means easy to explain their exact cause. By some this type of hernia has been supposed to be due to the abnormal development of a part of the gubernaculum, which extends into the perineum. By the action of this the testicle is not only drawn into the perineum, but along with it goes a fold of peritoneum, which forms the congenital sac, thereby producing all the necessary conditions for the hernia.

Personally, I have operated upon six such cases, the largest one of

which is well shown by the accompanying cut (Fig. 37). In this case the testicle, which was small and greatly atrophied, was removed. In the other cases it was transplanted into the empty scrotum. Only very few cases have thus far been reported.

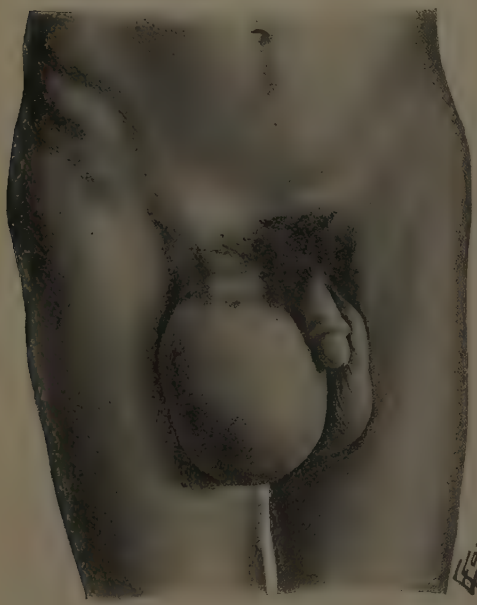

Fig. 37.—Inguino-perineal Hernia.

Methods of Operation for the Radical Cure of Inguinal Hernia.—Czerny's method was very widely used up to 1890 or even later. The procedure consists in an open incision over the external ring; exposure and isolation of the sac; ligation of the sac as high as was possible without cutting up the aponeurosis of the external oblique; dissection of fundus of sac (a step added later); closure of external ring by means of interrupted catgut sutures. The results of this operation were not particularly satisfactory, the mortality in non-strangulated cases being about 7 per cent., and the cases traced beyond two years showed 30 to 40 per cent. relapses.

Championnière's method consists in slitting up the aponeurosis of the external oblique well above the internal ring, thus securing a high removal of the sac. The canal is then closed by overlapping the aponeurosis of the external oblique by a series of mattress sutures.

Bassini's Method.—Bassini[33] in 1885 (published in 1888) introduced a new principle in closing the canal, namely, the transplantation of the cord. This method has given superior results to all others, and is at present so extensively employed that a careful description will be given (see illustrations made

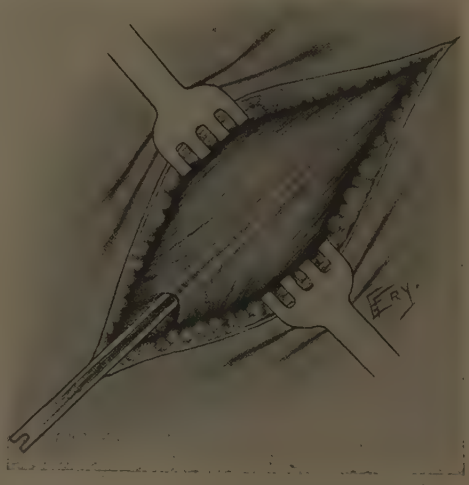

Fig. 38.—Bassini Operation. First Step. Aponeurosis of the external oblique exposed and director passed in.

from life of the author's own cases): A straight oblique incision is made, beginning at the inner side of the anterior superior spine and ½ inch internal to and parallel with Poupart's ligament, and ending over the center of the external ring. This incision is about 3 to 3½ inches long in adults, and 2½ to 3 inches in children. The aponeurosis of the external oblique having been clearly exposed, a director is passed in at the external ring beneath the aponeurosis for a distance of about 2½ inches (Fig. 39). The aponeurosis is then slit up with a scalpel upon a good director, great care being taken not to cut any underlying muscular fibers or the ilio-inguinal nerve. The aponeurosis is thereupon dissected back on the inner side, nearly to the edge of the rectus muscle, and on the outer side until the shelving process of Poupart's ligament is well exposed. The soft tissues on a level with the external ring, or slightly within it, are then grasped with a pair of thumb forceps, and the muscular fibers pushed aside by means of a pair of blunt-pointed curved scissors. The white tissues of the sac are thus quickly exposed and held by a pair of artery forceps. The sac and cord are then easily and quickly separated from the overlying tissues without hemorrhage, with the thumb and forefinger. In oblique hernia the sac will always be found anterior to the cord, to which it is closely attached by means of a thin layer of fascia, the infundibuliform fascia, which surrounds the two in common. By grasping the sac with a pair of artery clamps high up within the external ring, the cord is quickly and easily separated from

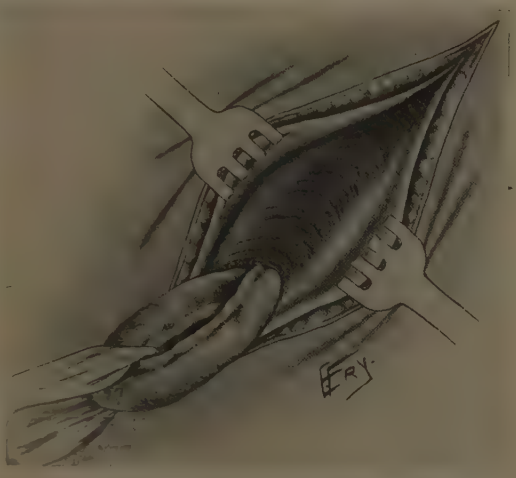

FIG. 39.—BASSINI OPERATION. SECOND STEP.
Sac and cord dissected *en masse*.

FIG. 40.—BASSINI OPERATION.
Isolation and ligature of the sac.

the sac by means of the thumb and forefinger of the right hand, assisted by a small pad of sterile gauze. After one gets beneath the infundibuliform fascia the dissection is extremely easy, and the cord now lies well below and free from danger. The outer portion or roof of the sac is first cut across to see that it is empty; then the floor is cut and the upper end of the sac is dissected well beyond the neck, or to a point where the sac widens out into the general peritoneal cavity. At this point the sac is transfixed with a catgut ligature and tied off (Fig. 40). If the sac be congenital, just enough of the lower portion to cover the testicle is allowed to remain, this being closed by continuous catgut suture. The internal oblique muscle should never be cut; in fact, no tissues beneath the aponeurosis are cut. Cutting the internal oblique muscle is entirely unnecessary for the complete removal of the sac. The cord is now held up out of the field of operation by means of a narrow strip of sterile tape or gauze. Next, the deep sutures of kangaroo tendon or chromicized catgut are introduced by means of a curved Hagedorn needle, preferably with the fingers, without a holder, as shown in Figs. 41, 42. The first suture enters the internal oblique muscle nearly as far as the outer edge of the rectus muscle, and is so placed that it just touches the lower border of the cord when the latter is held vertically to the plane of the abdomen. The suture passes outward, first picking up the cremaster muscle, then the shelving edge of Poupart's ligament, and is finally tied. Three or four similar sutures complete the closure of the canal as far as the symphysis pubis. I believe the lowermost suture is one of the most important in the series. My own practice is to insert the suture in such a way as to include the reflected portion of the external oblique aponeurosis as well

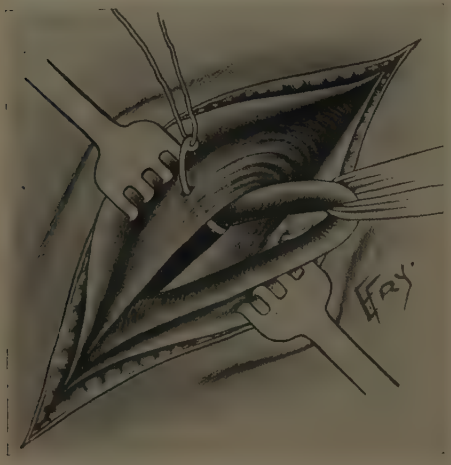

FIG. 41.—BASSINI OPERATION.
Showing the way the cremaster muscle is utilized.

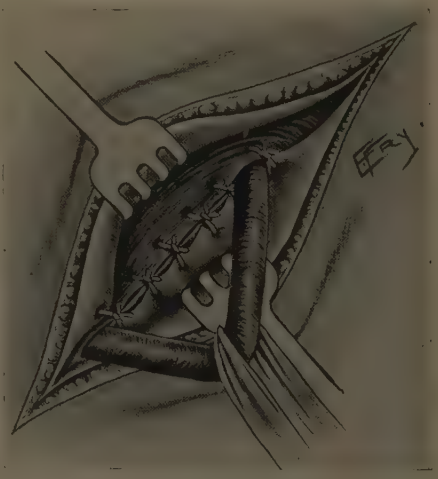

FIG. 42.—BASSINI OPERATION.
Deep sutures. Showing extra suture above the cord.

as the conjoined tendon and the transversalis fascia. This apparently is not usually done, according to the previously published cuts of Bassini's operation. In addition to the four or five sutures below the cord, I believe it a wise precaution to place one suture above the cord, passed through similar structures to those below. This is not strictly a part of Bassini's technic, but I believe that it undoubtedly strengthens the canal in its weakest portion at the internal ring, thus lessening somewhat the liability to recurrence. The incision in the aponeurosis is next closed by means of a continuous suture of kangaroo tendon of little finer caliber, the cord lying directly beneath this layer (Fig. 43). Care should be taken to leave sufficient room at the lower end or new external ring to permit the cord to pass out without undue constriction. The skin wound is then closed without drainage, by means of interrupted sutures of fine catgut. These sutures are almost always found absorbed at the time of the first dressing at the end of one week. It should be stated that Bassini himself uses silk for the buried sutures.

FIG. 43.—BASSINI OPERATION.
Aponeurosis sutured over the cord.

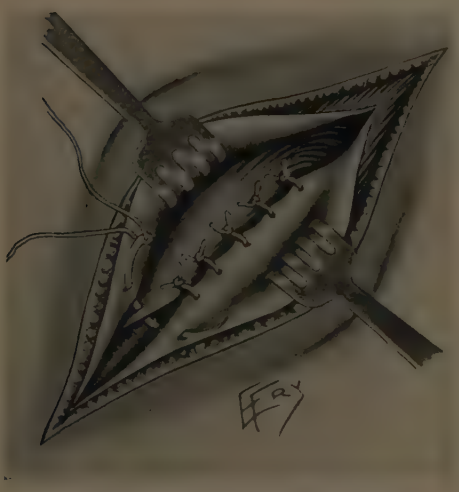

FIG. 44.—MODIFIED BASSINI OPERATION.
Suture of the internal oblique to Poupart's ligament without the transplanting of the cord (Bull and Coley).

Kocher's Method.—Consists in thorough isolation of the sac; making a small slit in the aponeurosis of the external oblique (which has thus far remained intact), about 1½ inches above the external ring; drawing the sac through this opening and laying it back upon the outer surface of the aponeurosis; closure of the canal by a series of interrupted Lembert sutures inserted so as to bury the sac in a fold of aponeurosis.

Bassini's Method, Omitting the Transplantation of the Cord (Modified Bassini) (Fig. 44).—In 1892 Bull and myself began a series of operations at the Hospital for Ruptured and Crippled, by the method of Bassini, omitting the transplantation of the cord. The results of this method, as published from time to time,[34] have been practically as good as those following Bassini's operation, at least in children. Girard,[35] of Berne, published an operation which is practically a combination of Bassini's and Championnière's methods, omitting the transplantation step. The internal and external oblique are both sutured to Poupart's ligament and the outer edge of the aponeurosis is sutured in such a way as to overlap for ½ to ¾ inch the inner edge. He published a series of 560 cases with eight relapses, operated upon by this method. In 1900 Ferguson, of Chicago, described practically the same method as our modification of Bassini's method, and has attempted to prove its superiority to the Bassini method proper.

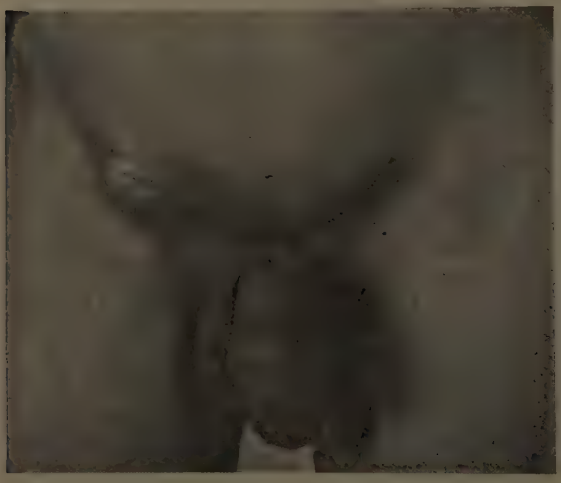

Fig. 45.—Relapse Following Bassini Operation.

A careful analysis of the cases thus far reported justifies the conclusion that the transplantation of the cord is not essential to the success of the operation, especially in children, while in adults, except in direct hernia, the results are nearly as good as in the cases in which the cord is transplanted. The principal theoretic objection to the transplantation step of the typical Bassini operation, so strongly emphasized by Ferguson, namely, the danger of atrophy of the testicle, resulting in sterility, has been shown to be without practical foundation. Atrophy of the testicle following Bassini's operation has never been observed at the Hospital for Ruptured and Crippled. Many of the children operated upon from ten to fifteen years ago have grown into adult life, have married, and are the fathers of children.

The time required for operation is about the same for the typical Bassini as for the modified operation, *i. e.*, without the transplantation step. Either method can be performed in eight to ten minutes by a surgeon familiar with the technic. The omission of the transplantation step seems too slight a modification of the Bassini operation to justify any one in claiming it as an original method. It is the same method Bassini himself employed for the radical cure of inguinal hernia in the female. I still believe that the typical Bassini method will give slightly

better results in oblique inguinal hernia in adults, and the transplantation step certainly has very great advantages in all cases of direct inguinal hernia.

FIG. 46.—FEMORAL HERNIA IN A CHILD AGED SEVEN YEARS.

FEMORAL OR CRURAL HERNIA.

Femoral or crural hernia may be defined as a protrusion through the crural canal. In the great majority of cases this protrusion occurs just at the inner side of the femoral vein. Very rarely the hernial sac is found directly over the vessels, this type being designated as external femoral hernia, examples of which have been described by Narath.[36] He discovered that this form of hernia was often the result of traumatism, particularly following attempts at reduction of congenital dislocation of the hip. Still more rarely the hernia may emerge external to the vessels, or the lacuna musculorum. The proportion of femoral hernia to inguinal hernia at the Hospital for Ruptured and Crippled has been about as 1 to 17, which is the same as that observed at the London Truss Society, according to the statistics of Macready.

FIG. 47.—FEMORAL HERNIA IN A CHILD AGED TEN YEARS OF TWO YEARS' DURATION.

Femoral hernia, as a rule, does not occur before puberty. At the Hospital for Ruptured and Crippled, out of 3404 cases of femoral 108 were in children under fourteen years of age.

Anatomic Relations. — The most important landmarks are the following: Poupart's ligament above, the pubic spine to the inner side, and the femoral veins to the outer side. As has already been stated, in some cases at least, femoral hernia is of congenital origin, due to the presence of a diverticulum of peritoneum into which the hernia later protrudes.

In acquired femoral hernia the development may be described as follows: The parietal peritoneum is

gradually pushed directly downward into the enlarged femoral canal, entering the sheath of the femoral vessels until it reaches the cribriform fascia, either penetrating the same or passing beneath it. At the lower end of the femoral canal it curves forward, emerging at the saphenous opening just internal to the femoral vein.

In very rare cases, as pointed out by Sultan, femoral hernia may leave the abdominal cavity in the usual way, emerging from the femoral opening, then passing through an opening in the pectineal fascia, continuing downward along the inner portion of the thigh, parallel with the vessels, instead of outward in the usual way. I have seen one such case as this, in which the hernial sac extended 3 inches below Poupart's ligament.

FIG. 48.—UNUSUAL TYPE OF FEMORAL HERNIA.
Sac rising above Poupart's ligament and simulating properitoneal hernia.

Femoral hernia in most cases is globular in shape, seldom attains to a size larger than a hen's egg or goose egg, though in some cases it may reach the size of a child's head. In rare cases the hernial sac passes upward over Poupart's ligament, toward the anterior superior spine, and rests upon the aponeurosis of the external oblique. While I formerly believed that such cases were due to the hernia's following the line of least resistance, it now seems more reasonable to believe that such sacs are of congenital origin. I have seen three examples of this type of femoral hernia during the last year. (See Fig. 48.)

Excluding the rare cases of external femoral hernia, the spine of the os pubis forms the inner boundary of the sac; the fascia overlying the femoral vein, the outer boundary. The floor upon which it rests is formed by the continuation of the iliac fascia, while its roof is made up of the falciform process of the fascia lata and Poupart's ligament. The possibility of the anomalous origin of the obturator artery should always be considered when operating for femoral hernia. In 1 case out of every $3\frac{1}{2}$ the obturator artery arises from a common trunk with the epigastric. Treves states that in 54 out of 101 cases in which it thus arose it passed to the outer side of the ring, while in 37 it passed backward across the ring, and in 10 around it and to the inner side; the last position being

the most dangerous. Under such conditions the neck of the hernial sac may be almost entirely surrounded by an arterial ring or wreath, fully justifying its ancient name of corona mortis. While death from hemorrhage was formerly not an unusual result in operations for strangulated femoral hernia, it is an accident which seldom occurs with modern methods of operation, in which the tissues are freely exposed and the incision upon the neck is made from without inward, whereby any hemorrhage may be easily recognized and controlled.

Coverings of the Sac.—The subcutaneous tissue, fascia propria of Cooper, made up of the septum cruralis, femoral sheath and cribriform fascia, the subperitoneal fat and peritoneum, constitute the coverings of the sac.

Contents of the Sac.—The contents of the sac differ little from the contents of inguinal hernia. The omentum is more frequently found in femoral hernia than in inguinal hernia and, on account of the small opening, it becomes more quickly adherent and irreducible.

Clinical Symptoms.—In most cases there are few symptoms associated with the early development of femoral hernia. There is usually a history of a swelling appearing in the groin below Poupart's ligament either without any known cause or after some unusual abdominal effort. While pain or a sense of discomfort may accompany the swelling, the latter is so small that oftentimes a careful examination must be made before it can be recognized. Owing to the small opening and the sharp edge of the falciform process, femoral hernias are much more likely to become strangulated than inguinal. For the same reason gangrene develops much more quickly than in the inguinal variety.

Diagnosis.—The principal points in the diagnosis have already been referred to under General Diagnosis and under Inguinal Hernia. The conditions most likely to cause confusion with femoral hernia are: adenitis, psoas abscess, saphenous varix, lipoma, hypertrophy of the subperitoneal fat. The methods of differentiating these conditions have already been described.

Various errors in the diagnosis of hernia as well as their relative frequency are well shown by the statistics of Macready. He collected 824 errors in the diagnosis of hernia, 739 in men, 85 in women. Hydrocele was the most frequent source of error, occurring in 233 cases; inflammation of the testis in 107 cases, varicocele in 90; non-inflammatory conditions of the testis in 28, tubercular testis in 17, solid tumors of the testis in 13 cases, of inguinal hernia. In femoral hernia enlarged lymphatic glands were mistaken for a hernia in 115 cases, abscess 47, enlarged saphenous vein 9, psoas abscess in 7 cases. Labial hernia was mistaken for a cyst in 12 cases.

Operative Treatment of Femoral Hernia.—In the early operations for femoral hernia little more was attempted than to tie off the sac as high up as possible and close the skin wound. Up to 1890 the results of operation showed about 30 per cent. of recurrences. In 1894 Bassini[38] published his own method of operation for femoral hernia, which consisted in thorough removal of the sac, as high up as

possible, followed by closure of the canal by five or six interrupted sutures. "With a curved needle three sutures are inserted so as to unite Poupart's ligament with the pectineal fascia, the first being placed near the spine of the pubis, the second 0.5 cm. externally, and the third near the femoral vein. These sutures are not tied until three or four others have been inserted, the first through the edge of the falciform fascia, then the pectineal fascia, the lower suture entering just above the saphenous vein. The upper sutures, which draw Poupart's ligament backward to the pectineal line, are fastened. The other sutures, which bring together the anterior and posterior walls of the canal, are next tied." At the time of

FIG. 49.—OBLITERATION OF THE FEMORAL OPENING BY PURSE-STRING SUTURE.

publication, in 1894, Bassini had operated upon 54 cases by this method, with no mortality and without a single relapse in 41 cases traced from one to nine years.

During recent years there has been a tendency toward more and more complicated methods. At the present time the methods employed for the radical cure of femoral hernia may be divided into two main groups: first, those in which an effort is made to close the canal by means of a suture applied in a great variety of ways; second, those in which an attempt is made to close the canal by means of muscle, osteoplastic or heteroplastic flaps.

The operations of the first group may be subdivided into those methods in which an attempt is made to close the canal from the outer side; and those in which the canal is closed from the inner side through an opening in the inguinal canal.

The reasons advanced in favor of the more difficult and complicated operations for the radical cure of femoral hernia are all based on the supposition that femoral hernia is not curable by simpler methods. Ochsner[39] strongly advocates the simplest of all operations, namely, high ligation of the sac, removal of the extraperitoneal fat from the femoral ring, and closure of the skin. He has operated upon 56 cases at the Augustana Hospital in Chicago, and in 30 cases which he has been able to trace there has been no relapse. Ochsner believes that this simple operation is sufficient, because it rests upon the principle that it is practically impossible to keep a circular opening in any part of the body from closing spontaneously, unless it be lined with a mucous or serous membrane.

FIG. 50.—CUSHING-MARCY PURSE-STRING SUTURE FOR FEMORAL HERNIA.

DeGarmo,[40] of New York, reported 110 cases operated upon by a method practically the same as Bassini's, with the exception that a smaller number of sutures are used, with but a single relapse.

I have operated upon 142 cases of femoral hernia, in 127 of which a purse-string suture of kangaroo tendon was used, without a single relapse; in the 15 remaining cases Bassini's method was employed, with one relapse.

The purse-string method which I have used may be briefly described as follows (Fig. 49):

An oblique incision is made ¼ to ½ inch below Poupart's ligament and parallel with it, almost identical with the incision made for inguinal hernia, only slightly lower and a little shorter. The sac, with the mass of extraperitoneal fat that almost always surrounds it, is then freed well up into the femoral opening. The masses of fat are carefully removed; the sac itself, by gentle traction, is brought down well beyond its neck to a point where it widens into the general peritoneal cavity. It is always opened before ligature, to make sure that it is empty. If omentum is present, this is tied off and removed. The ligature having been placed well beyond the neck by transfixion, is carefully tied and the sac removed. When the stump of the sac has been pushed through the opening into the abdominal cavity, there is no longer any funicular process present in the femoral region. With a curved Hagedorn needle, threaded with kangaroo tendon of medium size, the suture is

placed as follows: The needle is first passed through the inner portion of Poupart's ligament or the roof of the canal, then downward, taking firm hold of the pectineal fascia and muscle, then outward through the fascia lata overlying the femoral vein, and finally upward, emerging through the roof of the canal about ¼ inch distant from the point of entrance (Fig. 49). On tying this suture, the floor of the canal is brought into apposition with the roof and the femoral opening is completely obliterated. The skin and superficial fascia are closed by means of an interrupted catgut suture and a sterile dressing is applied, without drainage. The first change of dressing is made at the end of one week. The patient is kept in bed for two weeks and allowed to go home at the end of two and a half weeks. A firm spica bandage is worn one week after leaving the hospital, at the end of which time no further support is needed.

Fig. 51.—Berger's Operation for Femoral Hernia.

The purse-string suture thus applied accomplishes exactly the same thing as Bassini's operation for femoral hernia, and it has the advantage that it is much more easily and quickly performed.

This method is the simplest of all operations for femoral hernia, with the exception of ligation of the sac without any suture of the canal.

Of 127 personal cases, 75 have been traced from one to fourteen years, without a relapse. These cases have in no way been selected and the method has been employed in the largest hernias with equally good results, and there have been no complications, with the exception of a slight phlebitis in one case, which soon disappeared.

In view of these practically perfect results from simpler methods, it seems unwise to advocate the complicated methods of Fabricius, Lotheissen, Gordon, Bardesca, and others.

RESULTS OF MODERN METHODS OF OPERATION FOR THE RADICAL CURE OF HERNIA

Pott[9] in 1903 presented the most complete study of the end results of operation for the radical cure of hernia up to that date.

Of a total of 4066 cases of inguinal hernia, 81.8 per cent. were permanently cured. Of these, 316 were females, with 84.8 per cent. of permanent cures.

As regards individual methods, 376 cases operated upon by Kocher's method showed 92.5 per cent. of permanent cures; 1851 cases operated upon by Bassini's method showed 90.1 per cent. of permanent cures; 1419 cases operated upon without slitting up the aponeurosis of the exterior oblique showed 71.6 per cent. of permanent cures; while 2502 cases operated upon by methods in which the aponeurosis of the exterior oblique was slit up, showed 88.4 per cent. of permanent cures.

The results of operations for the cure of femoral hernia showed 70.5 per cent. of permanent cures in a total of 424 operations. Of these, 158

were operated upon without suture of the femoral ring, resulting in 63.3 per cent. of permanent cures, while in 155 operations with suture of the femoral ring 71.6 per cent. were permanently cured.

Eighty-six cases of abdominal hernia operated upon by various methods showed 54.7 per cent. of permanent cures.

A few of the more important individual statistics show the following results:

Championnière[23] reports 21 relapses in 650 cases operated upon by his own method. Bassini's original report[33] gives 262 cases with 7 relapses; Bassini, reported by Frantz, 593 cases with 28 relapses. Brenner[37] reports 2000 operations in 1188 individuals—1080 men and 108 women—operated upon at the Lindz Hospital in Austria from 1892 to 1903, by Bassini's method, with 5 deaths in the non-strangulated cases. Of 369 cases in which operation was performed on both sides, a hernia was present only on one side.

Of 991 operations for the radical cure of hernia in the male, 91.8 per cent. resulted in a permanent cure; of 82 operations upon women, 95 per cent. were permanent cures.

Goldner (Bassini's method) reported 800 cases with 35 relapses. Carli (Bassini's method) reported 601 cases with 36 relapses. De Garmo's statistics up to January, 1907, show 1411 operations in 1031 patients, 757 males and 274 females, 239 of the cases being below fourteen years of age, 792 above that age. Of these 1411 operations, 1237 were performed for inguinal hernia, Bassini's method being used in 1205 of same.

The total number of relapses is given as 19, 9 of which were re-operated upon. As regards the mortality, there were 8 deaths in 1257 non-strangulated cases, 9 deaths after 43 operations for strangulated hernia.

De Garmo's statistics further show 119 cases of femoral hernia, operated upon by his own method with only one relapse; 35 cases of umbilical hernia and 20 cases of ventral hernia. Bull, Coley and Walker, in a series of 1209 cases of inguinal hernia in the male, operated upon at the Hospital for Ruptured and Crippled between 1890 and 1908, by Bassini's method, had 9 relapses, or $\frac{7}{10}$ of 1 per cent. Or, 2200 operations for all varieties of hernia, performed by the same operators, showed 19 relapses, being $\frac{8}{10}$ of 1 per cent.; 85 operations for femoral hernia with no relapses.

Girard (modified Bassini method with overlapping of aponeurosis, cord not transplanted) reported 545 cases (1892 to 1900) with 8 relapses; Wölfler (modified Bassini method) (1895 to 1902), 828 cases with $7\frac{1}{2}$ per cent. relapses; Ferguson (modified Bassini method) (1898 to 1907), 356 cases with 4 relapses; Ochsner (modified Bassini method), 283 cases with 3 relapses.

Bull, Coley and Walker (modified Bassini, cord not transplanted), at the Hospital for Ruptured and Crippled (1892 to 1907), operated upon 340 cases in the male with 4 relapses; 400 in the female with 2 relapses. Or, 740 cases with 6 relapses $= \frac{8}{10}$ of 1 per cent. There were 6 deaths.

My personal statistics show 20 relapses in 2032 operations, 14 in 930 patients over fourteen years and 6 in 1102 under fourteen years. There was one death in the former group, and three deaths in the latter.

HERNIA OF THE CECUM AND APPENDIX.

The cecum alone or appendix alone, or both, may be found in the sac of either inguinal or femoral hernia. Such cases have been reported as far back as the end of the eighteenth century. Tritschler (Wood)[41] wrote on hernia of the cecum and appendix in 1806, and Rust on hernia of the appendix in 1832 ("Handbuch d. Chir."). The frequency with which the cecum and appendix occur in the hernial sac may be fairly determined from the operative statistics of recent date. Of 1586 hernias operated upon in the clinic of Colzi, Florence, the appendix was present in 27. At the Hospital for Ruptured and Crippled in 2200 cases of hernia operated upon from 1890 to March, 1908, the cecum and appendix either alone or in combination were found in 36 cases; the cecum alone in 18, the appendix alone in 10, the sigmoid in one, the cecum and appendix together in 7. In not a single one of these cases was the appendix found in a femoral hernia. The cecum is more often found than the appendix, as shown by the above statistics; the appendix alone more frequently in inguinal than femoral hernia, but the difference is less marked than one would suppose.

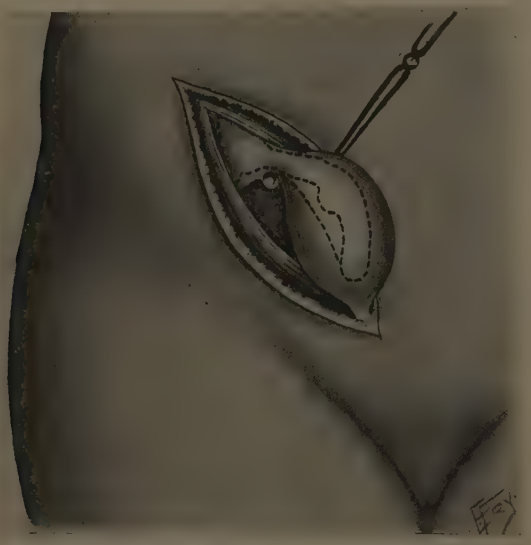

FIG. 52.—INCARCERATED HERNIA OF THE APPENDIX WITH SAC DISTENDED WITH BLOODY FLUID.

Of 145 cases collected by Spurrier and Corner, 71 were inguinal and 69 femoral. Of 63 cecal hernias collected by Gibbon, 56 were inguinal and 7 femoral, all of the latter occurring in women. The appendix was absent in 15 of the 56 cases of inguinocecal hernia and present in all of the 7 cases of femoral hernia. Only one of the inguinal hernias occurred in a female, and this was a pure appendicular hernia. The author has had one case in a female; this was also a hernia of the appendix operated upon for acute strangulation (Fig. 52). The patient made a good recovery.

Wood has made the most complete study of appendicular femoral hernia of which I have knowledge. He has collected 100 cases, of which 81 occurred in women, 7 in men; in 12 the sex was not stated. More than half of the cases of cecal hernia occurred in patients under the age of fifteen years, while in hernia of the appendix alone, more than half had been found in patients over the age of fifty years.

Etiology of Cecal and Appendicular Hernia.—I believe an unobliterated pouch of peritoneum to be the primary cause, certainly in the inguinal and probably in many of the femoral hernias. In addition, there must be an abnormally movable cecum.

The immediate or exciting causes are much the same as those in cases of ordinary inguinal and femoral hernia, *i. e.*, severe strain or abnormal increase in intra-abdominal pressure.

In the case of sliding hernia of the cecum, of which the author has seen 8 cases, the etiology is entirely different. In these cases there may be no abnormal mobility of the cecum, and there may be likewise no preformed or congenital pouch of peritoneum in the canal. The cecum occupies an abnormally low position; the peritoneum surrounds the cecum only on its anterior and lateral surfaces, while posteriorly it is loosely attached by connective tissue which permits the entire cecum to be gradually forced downward into the inguinal canal. There is probably also present as a predisposing cause in these cases an abnormally large external ring. I believe that intra-abdominal pressure due to straining, lifting, or coughing, which is so frequently the cause of the ordinary type of inguinal hernias, plays but a minor rôle in the production of sliding hernias; it is rather a regular, constant pressure which gradually forces the cecum to a lower and lower position, until finally it is in the inguinal canal. In these cases the hernia can never be fully reduced and, hence, never be perfectly controlled by a truss.

Inasmuch as the appendix is seldom present, the diagnosis of hernia of the appendix is rarely made before operation. Yet in infants and young children the author believes the diagnosis in most cases is comparatively easy. At the Hospital for Ruptured and Crippled, in children the diagnosis has been frequently made, and afterward confirmed by operation. One can readily outline the appendix in the thin-walled sac, and the only condition likely to simulate it would be a hernia of the tube and ovary. However, in ovarian hernia there is much greater tenderness, which fact would enable one to differentiate the two conditions. In addition, the tumor is more globular. In simple reducible hernia of the appendix there are no symptoms characteristic of the condition. In the presence of an inflamed and adherent appendix there may be nausea, vomiting, constipation, and, in fact, the symptoms may closely resemble strangulation.

Of the 100 cases of appendicular femoral hernia collected by Wood, the appendix was returned into the abdominal cavity without operation in 17 cases, with one death; in 52 it was resected, with three deaths.

I cannot agree with the opinion of Wood, that the appendix is more often found in femoral than in inguinal hernia. I have operated upon 140 cases of femoral hernia and have never seen a hernia of the appendix, while in 1874 cases of inguinal hernia it has been found in 36 cases.

Treatment.—The appendix when found in the hernial sac should, as a general rule, be removed, unless there are strong contraindications. If the appendix is found in a femoral sac, it may be wiser in some cases to return it, for the reason that it may not be possible to bring the cecum down sufficiently into view to make a satisfactory removal.

In cases of appendicitis complicated with inguinal hernia the operation advocated by Torek is much to be commended. This consists in prolonging the oblique skin incision upward by about one inch and then also carrying up the incision in the aponeurosis a little higher than usual. By retracting the aponeurosis well, one is able to do the typical gridiron method of McBurney. After the appendix has been removed, the appendix incision may be closed as far as the aponeurosis and then the usual Bassini method be employed for the hernia. I have used this method in several cases with much satisfaction.

HERNIA OF THE URETER.

The ureter has been found in both inguinal and femoral hernia; however, the condition is an extremely rare one. A most careful study of the subject has been made by Carli,[42] of Pavia, Italy, who was able to collect but nine cases from the literature, to which he added two observed at Muscatello's clinic. These hernias may be divided into two groups: (1) Simple ureteral hernia—those in which the ureter only has entered the hernial sac; (2) ureteral hernia combined with rupture of the bladder, in which cases both ureter and bladder are found in the sac.

This classification holds good for both inguinal and crural hernia. Of the 11 cases reported by Carli, 6 were inguinal, 5 crural; only 2 occurred in oblique inguinal hernia, the remaining 4 in direct hernia in combination with a portion of the bladder. All occurred on the right side.

The crural variety were all simple ureteral hernias, two occurring on the right, three on the left side.

The ages of the patients ranged between nine and sixty-three years.

All the ureteral hernias of the crural variety occurred in women; all the inguinal in men.

The etiology is obscure. Reichel[43] believes that a possible explanation may be found in the assumption of adhesions occurring between the testicle and ureter during intrauterine life, in consequence of which the ureter is dragged downward by the testicle into the vaginoperitoneal canal. Thus far there is no proof of such origin, as all the cases hitherto reported have apparently been caused by a sliding process similar to that observed in many cases of sliding hernia of the cecum or sigmoid.

HERNIA OF THE BLADDER.

The etiology of bladder hernia is most obscure. It has been supposed until very recently that bladder hernia was a condition found only in adult life, but as the number of operations for hernia in children has greatly increased within the last few years, it has been found that hernia of the bladder occurs nearly as frequently in children as in adults.

Carmichael[44] reports 3 cases of bladder hernia in 152 operations for hernia in children, 44 of which were under the age of one year.

At the Hospital for Ruptured and Crippled, only 3 cases of bladder

hernia have been observed in upward of 1900 operations for the radical cure of hernia in children between four and fourteen years of age.

Dilatation of the bladder, weakness of the bladder wall, loss of normal power of contractility, associated with a hernia already well developed, are supposed to be more or less important factors in the etiology of bladder hernia.

While hernia of the bladder was first recognized by Platerus in the early part of the seventeenth century, it is of comparatively rare occurrence. Brunner,[45] in 1890, was able to collect only 180 cases, of which 136 were inguinal, 122 occurring in males; 29 femoral bladder hernia, 27 occurring in women. Bladder hernia may be intraperitoneal, extraperitoneal, or paraperitoneal. Of Brunner's cases, 5 were extraperitoneal, 18 intraperitoneal, and 100 paraperitoneal. In only 13 of the 180 cases was the diagnosis made before operation. Even during operation the condition has often remained unrecognized until the bladder was accidentally opened, and, in some cases, with disastrous results. One of the most important signs pointing to bladder hernia is the presence of a mass of extraperitoneal fat in the upper and inner portion of the sac. In the event of opening the bladder, the best method of treatment is immediate closure with interrupted sutures, in two layers; the bladder is then reduced into the abdominal cavity. The bladder should be drained by a catheter left in the urethra for three or four days. In addition, it is wise to insert a small cigarette drain in the hernial wound, to the site of the bladder wound in case of leakage. In some cases the injury to the bladder has not been recognized until after the operation was completed. In such instances the wound should be immediately reopened and the bladder treated as just described.

HERNIA OF THE UTERUS, TUBE, AND OVARY.

Hernia of the uterus is very rare, only 37 cases having been reported up to 1905 (Hilgreiner[46]). The condition is most often found in middle-aged women who have borne children. In nearly one-half of the reported cases the condition was associated with defects and malformations of the genital tract, *e. g.*, uterus bicornis, uterus bipartis, uterus duplex, or absence of one ovary, or pseudo and true hermaphrodism.

The uterus has been found more often on the right side than on the left in inguinal hysterocele. The uterus has very seldom been found alone in the sac, but usually in conjunction with the tube or ovary or with a portion of the bowel; in six of the reported cases a loop of small intestine was present. In a few cases a testis was found in addition to the uterus. In eight cases in which the condition was complicated with pregnancy the diagnosis was made before operation, but rarely in the other cases. In most instances a careful bimanual examination, together with the history of the case, should enable the surgeon to make the diagnosis. The conditions most likely to simulate hernia of the uterus are hernia of the tube and ovary, irreducible omentum, and extrauterine pregnancy.

Treatment.—The hernia is usually irreducible and early operation is the only treatment to be considered. The result of the operation depends generally upon whether the uterus is gravid or not. In the eight cases associated with pregnancy, cesarean section was performed in five, the children living in each instance, while in four out of the five cases the mothers died. (It should be noted, however, that all these cases occurred in pre-antiseptic times.) In three cases incarceration of the hernia was present. If operation is not too long delayed, the prognosis should be good.

F. T. Andrews,[47] of Chicago, has made the most complete collection of hernias of the female pelvic organs so far published. He reports 366 cases, of which 46 were hernia of the tube, without the ovary; 80, hernia of the ovary and tube; 176, hernia of the ovary without the tube or latter not mentioned; 43, hernia of the non-gravid uterus; 30, hernia of the pregnant uterus.

Of the 46 cases of hernia of the tube without the ovary, 27 were inguinal and 14 femoral, 2 obturator, and in 3 the variety is not stated.

The ages of the patients ranged between birth and forty-six years.

Seventeen of the 27 cases of inguinal hernia recovered after operation; 3 died. In 5 the hernia was found post-mortem.

Andrews states that hernias of the Fallopian tube without the ovary constitute 10 per cent. of the published cases of hernia of the pelvic organs. At the Hospital for Ruptured and Crippled we have had 4 cases of tube and ovary in the hernial sac and have operated on two additional cases.

UMBILICAL HERNIA.

There are three varieties: (1) Congenital hernia of the cord; (2) infantile umbilical hernia; (3) umbilical hernia of adult life.

Fig. 53.—Hernia of the Umbilical Cord (Author's case).

Hernia of the Umbilical Cord.—Congenital hernia of the umbilical cord is an extremely rare condition. According to Lindfors, it occurs only

once in 5184 cases. It is due to imperfect agglutination of the visceral plates in the region of the umbilicus during fetal life. This type of hernia is, strictly speaking, not so much an actual protrusion of the abdominal viscera as it is an imperfect closure of the viscera by the abdominal wall during fetal life. Not infrequently this variety of hernia is associated with other developmental defects, *e. g.*, hare-lip. The condition more closely resembles ectopia of the bladder than a true hernia. The covering of a hernia of the umbilical cord consists of: (1) a thin layer of Wharton's jelly; (2) a thin membrane or sac which is continuous with the parietal peritoneum.

These two layers are exceedingly thin, so that the underlying viscera can be easily seen and recognized. The size of the hernia varies from that of an English walnut to the size of a child's head and complete eventration. Only four cases have been observed at the Hospital for Ruptured and Crippled during the last eighteen years in a total of over 75,000 cases of hernia; two of these I operated upon within a single week. The other two cases were of smaller size and were cured by mechanical means. In cases of small size the only thing pointing to a hernia of the umbilical cord may be an abnormal thickening of the cord near the base, and in such cases it is well to tie the cord at some distance from the abdominal wall, as otherwise the intestine might be injured. In hernia of any size the diagnosis is easy.

FIG. 54.—HERNIA OF THE UMBILICAL CORD (Author's case).

Treatment.—If the hernia is of small size a cure may be obtained without operation by carefully cleansing the parts, keeping them as nearly aseptic as possible, applying pressure to the hernial tumor by means of straps of adhesive plaster encircling the entire abdomen. I have treated two cases in this manner with perfect result.

In the case of a hernia of the umbilical cord of large size, operation is required. In one of my own cases I removed as far as possible the outer layer of Wharton's jelly, not opening the peritoneal cavity. The edge of the abdominal wall at the base of the hernial tumor was then cut away sufficiently to leave a raw surface on either side; then, by means of silk and silkworm-gut sutures, an attempt was made to close the opening

as far as possible. The tension of the sutures was relieved by strips of rubber plaster. In some cases it will be impossible to bring the edges into apposition, yet even then something will be gained by the sutures by way of partial closure greatly diminishing the size of the opening. The wound requires careful daily dressing. In some cases it may be wise to do an intraperitoneal operation, but I believe that most of the cases can be successfully treated without opening the peritoneal cavity. The most favorable time for operation is the second or third day.

The **prognosis** is good, considering the serious nature of the condition. MacDonald, in 1890, collected 31 cases, of which 12 were treated by bandage compression, with 9 deaths, and 12 were treated by operation with 2 deaths. Lindfors, in 1893, collected 44 cases; of these, 32 were treated by operation, with 6 deaths.

Fig. 55.—Large Umbilical Hernia in an Infant.

Ritterhaus[48] has collected 153 cases of hernia of the umbilical cord up to the beginning of 1907.

As regards the treatment employed, Adler (Dissertation, Zürich, 1904) found 72 laparotomies recorded up to 1904, since which time 22 further laparotomies have been reported. Of these 94 cases, 65 were cured; 29 died within a few days after operation. This gives a mortality of 31 per cent. in an affection which, up to the beginning of the last century, was generally considered as fatal.

Umbilical Hernia in Children, or Infantile Hernia.—Umbilical hernia is far more common during the first year of life, and at this period it is found with almost equal frequency in the two sexes. This is true up to the age of ten years. Of 209 cases of umbilical hernia in males observed by Macready, 108, or more than 50 per cent., occurred during the first year of life; while of 566 in the female, 100 occurred during the first year of life. Only 2 males and 13 females developed umbilical hernia between the age of six and twenty years. In brief, one-half of the cases of umbilical hernia in the male occurred in the first year of life, against one-fifth in umbilical hernia in the female. After the age of twenty the number begins to increase slowly in males and rapidly in females, owing to the beginning of the child-bearing period. Taken as a whole, umbilical hernia is 2.7 times more common in the female than in the male. At the Hospital for Ruptured and Crippled our statistics

show the following relative proportions between the sexes of inguinal, femoral, and umbilical hernia:

	Inguinal Hernia.	Femoral Hernia.	Umbilical Hernia.
Male	48,252	990	2596
Female	8,726	2414	4622

Macready's[4] statistics at the London Truss Society are as follows:

	Inguinal Hernia.	Femoral Hernia.	Umbilical Hernia.
Of 100 males	96.33	2.53	1.14
Of 100 females	50.5	33.5	15.8

Among 100 ruptured persons are: Inguinal, male, 83.5 per cent.; inguinal, female, 8.5 per cent.; femoral, female, 5.9 per cent.; femoral, male, 2.1 per cent.

In the normal infant the umbilical opening in the abdomen is just large enough to allow the passage of the umbilical cord and vessels. After the cord has separated there remains a small area of granulation which quickly heals. In many infants this opening is abnormally large and the thin tissue gradually yields to the intra-abdominal pressure with the result that an infantile umbilical hernia is produced. The vein occupies the upper part of the cord and, being less firm than the artery, the hernia usually appears at the upper, rather than the lower, margin of the ring. Such hernias vary much in size, ranging from the size of a cherry to that of an egg. Many disappear spontaneously from the gradual obliteration of the opening due to the development of the abdominal muscles. Strangulation is extremely rare. Inasmuch as nearly all cases may be cured by mechanical support, operation is seldom advised.

Fig. 56.—Umbilical Hernia in Adult. Adherent omentum. Protrusion absent by reason of thick layer of fat.

The method of treatment has already been described under Treatment of Hernia in General.

Large Umbilical Hernia of Adults.—Here we have an entirely different class of cases. The majority develop in women who have borne children and, hence, appear between the ages of thirty and forty. They are most often found in stout persons who have borne several children. As the fatty layers of the abdominal wall increase, the muscles decrease in size and tone and the resulting relaxation affords a favorable condition for the development of umbilical hernia. In the very fat the hernia may attain considerable size without showing any noticeable tumor. In umbilical hernia in adults, especially in women, there is a strong tendency to early adhesions between the contents of the sac and the sac. The omentum is always found in this variety of hernia, either alone or in conjunction with the intestine. The colon is more frequently found than the small intestine, though in very large hernias both large and

FIG. 57.—LARGE UMBILICAL HERNIA. INOPERABLE.

small intestine may be present. I recently operated upon a case of very large recurrent umbilical hernia, nearly twice the size of the adult head, in which the sac contained the transverse colon, sigmoid, cecum and appendix, practically the entire small intestine, and the stomach. There was a strong tendency to the formation of trabeculæ and diverticula in the sac, dividing the cavity of the sac into a number of separate compartments.

The diagnosis of umbilical hernia in adults is not usually difficult. There is nearly always a history of slow development of a tumor, at first reducible, later becoming irreducible, often increasing in size, especially with any increase of intra-abdominal pressure.

Physical examination will show the characteristic "feel" of omentum or of omentum and bowel combined, in which case a tympanitic note will appear on percussion over certain areas. The only condition likely to be mistaken for such a hernia would be a subperitoneal lipoma in the region of the umbilicus. However, such tumors are not likely to appear at the exact site of the umbilicus and the history of their development is quite different. There is never a period of reducibility; the gastric disturbances which are frequently seen in umbilical hernia are absent in lipoma. Besides, subperitoneal lipoma in the umbilical region is a very rare condition.

FIG. 58.—UMBILICAL HERNIA WITH SMALL PEDICLE.

Accidents and Dangers Connected with Umbilical Hernia in Adults.—The omentum at first becomes adherent and later the intestine is present. Attacks of obstruction and inflammation are fairly frequent; even strangulation is not rare. Strangulated umbilical hernia is a far more serious condition than strangulation in the inguinal and femoral varieties, and the mortality is not far from 50 per cent. Blake,[49] of New York, has operated upon a remarkable series comprising eight cases with three deaths, or a mortality of 37.5 per cent. Resection was done in four cases with two deaths. In four cases no resection was performed and three of these were cured.

In very rare cases suppuration may take place as a result of infection, most often of the colon bacillus, from the adherent intestine, or of infection from an abrasion of the skin. I recently had a case of suppurating omental umbilical hernia in a woman sixty-four years of age. The patient was very stout and the umbilical hernia had not been noticed before. She was suddenly attacked with pain in the region of the umbilicus, had a temperature of 102° to 104° and marked prostration. The hernial tumor was the size of two fists, markedly tender, the skin was reddened and adherent; the leukocyte count was 30,000; the bowels were regular with no evidence of obstruction. The diagnosis of omental hernia was made, and shortly afterward an opening occurred spontaneously with evacuation of about a pint of fetid pus. Bacteriologic examination showed a pure culture of colon bacillus. The adherent omentum could be felt at the bottom of the sac. On account of the age of the patient and her general bad condition, no radical operation was performed. The wound was enlarged under cocain and free drainage established. The patient made a good recovery, without a more extensive operation, which would probably have proved fatal.

Treatment of Umbilical Hernia.—The **mechanical treatment** of umbilical hernia in adults consists in applying a carefully fitted abdominal belt, made of some strong material, *e. g.*, linen duck or canvas, with elastic straps, or of woven silk elastic with non-elastic straps. The front of the belt should be sufficiently deep to prevent it from changing its position and not too concave. Most cases require a pad of some firm material, such as hard rubber or wood, covered with chamois skin. A flat, convex pad is preferable in reducible hernia, while in irreducible hernia, especially of considerable size, a concave pad should be used. The size of the pad should be about double that of the umbilical ring. In very large hernias the belt may require support from the shoulders.

Operative Treatment of Umbilical Hernia.—Large umbilical hernia in the adult is one of the most difficult of all varieties of hernia to treat and requires the exercise of the greatest judgment. The ideal method of treatment would be immediate operation in the early stages and before the hernia attains any great size. If the operation were done at this time nearly all cases could be cured, and we should not have to deal with the enormous irreducible hernias that now so often task the judgment and skill of the surgeon. While operation should seldom be advised in umbilical hernia in children, it should always be advised in hernias of small or moderate size in adults. Whether we should operate upon the very large umbilical hernias containing most of the omentum and a large portion of the intestine, bound together with numerous adhesions, is a question upon which opinions still differ. Up to very recently I have been inclined to advise against operation in such cases, on the ground that

the mortality is necessarily considerable and that recurrences have been numerous. The Mayos,[50] of Rochester, Minn., have proved that most cases of umbilical hernia, even of very large size, can be really cured by the overlapping operation which they devised about ten years ago, so that the only reason that still obtains against operation is the danger associated with operation. The operation upon such cases (the very large irreducible hernias) is one of the most difficult in surgery, and should not be undertaken without large experience and sufficient well-trained assistants, and even then, I believe, the mortality is at least 10 per cent.

In cases in which operation is indicated, the Mayo operation is, I believe, by far the best.

FIG. 59.—MAYO'S OPERATION FOR UMBILICAL HERNIA (Mayo).

Mayo's Operation for Umbilical Hernia.—The method is extremely simple and is well shown by the accompanying cuts (Figs. 59, 60, and 61). It consists in a large, transverse, elliptic incision, with the removal of the umbilicus and the redundant portion of skin and fat, the fascia together with the omentum, if adherent. The fascial ring is then enlarged on either side, until it reaches the edge of the rectus muscles. Then the fascia, including the peritoneum, is overlapped by means of interrupted mattress sutures, so that the lower layer lies underneath and the upper layer externally. The edge of the upper flap is then fastened down upon the surface of the underlying flap by continuous suture, after which the skin

is united. The Mayos have operated upon 127 cases, 75 cases of which have been traced, with only one partial relapse.

FIG. 60.—MAYO'S OPERATION FOR UMBILICAL HERNIA, SECOND STEP (Mayo).

FIG. 61.—MAYO'S OPERATION FOR UMBILICAL HERNIA, THIRD STEP (Mayo).

These results are far superior to those of any other method and demonstrate the superiority of the Mayo operation.

Shortly after the publication of the Mayo operation, Blake,[49] of New York, described a new operation for umbilical hernia, consisting in vertical overlapping from side to side. While Blake and others have obtained excellent results with this method, in the majority of cases I believe the Mayo operation to be preferable, except in cases in which there is much divarication of the recti muscles, in which event Blake's method may be superior.

Very recently Graser[51] has described a new operation for large umbilical hernias which has some points in common with both Mayo's and Blake's operations, the transverse skin, as likewise the transverse fascia, incision being the same as in Mayo's operation. In addition, Graser dissects out the recti muscles, opens their sheath, and unites the muscles vertically, and then closes the fascia and skin transversely.

While Graser's method has, theoretically, some advantages over the Mayo operation, it is more complicated and lacks the overlapping feature of the Mayo operation, which is probably the most important step of all.

FIG. 62.—VERTICAL OVERLAPPING METHOD FOR UMBILICAL HERNIA (Blake).

VENTRAL HERNIA.

A hernia which protrudes through some other portion of the abdominal wall than the inguinal, femoral, and umbilical rings, is usually termed a ventral hernia. The most frequent sites are the linea alba or linea semilunaris. When occurring between the umbilicus and ensiform cartilage, they are usually designated epigastric. There is another class of hernias characterized as ventral, though, strictly speaking, they are of traumatic origin, due to imperfect closure or suppuration of the abdominal wall after surgical operations. In these cases there is seldom a true sac, but a gradual thinning out of the scar tissue of the incision.

The relative frequency of epigastric hernia as shown by Berger's statistics (Paris) is 137 in 10,000 cases, 120 males and 17 females. Macready found only 38 cases of ventral hernia in the linea alba to 19,341 cases of inguinal and femoral hernia. This hernia usually appears between the navel and ensiform cartilage and, in most cases, within the first three inches above the umbilicus. Very often the hernial opening

is a transverse slit in the fascia, apparently due to a congenital defect. Hernias at the upper end, nearer the ensiform cartilage, are exceedingly rare.

Epigastric hernia shows several types or varieties: (1) a small mass of subperitoneal fat, without any sac; (2) in addition to the subperitoneal fat a process of parietal peritoneum attached to it, without any contents; (3) a sac containing omentum; (4) a sac containing intestine.

In nearly all cases, except in children, there is a thick layer of fat outside of the sac. Not infrequently these hernias are multiple, there being two or three small openings in the fascia, a short distance from one another and separated by a narrow band of fascia. Epigastric hernias are seldom of large size, varying from the size of a walnut to the size of an egg, though in rare cases they may reach the size of a closed fist. The diagnosis is not very difficult. The only condition closely resembling an epigastric hernia is lipoma. If the lipoma is of subperitoneal origin it may show all the characteristics of an omental hernia, even the impulse on coughing. This type of lipoma is often associated with an epigastric hernia, and has been supposed by many authors to be an important factor in the development of the hernia, the lipoma being supposed to exert sufficient traction upon the parietal peritoneum to draw it out until it becomes a true hernial sac. An ordinary lipoma, superficial to the fascia, will be more movable than a hernia; it will show no impulse on coughing, and one can usually make out the fact that there is no connection with the abdominal cavity. In women, even in cases of adherent omentum, one can usually get some impulse on coughing, and not infrequently the contents of the hernial sac become noticeably enlarged. The contents of the hernial sac usually consist of omentum alone. Graser (von Bergmann's "Surgery," article on Hernia) states that the majority of cases contain omentum and transverse colon, but this has not been found in the cases observed at the Hospital for Ruptured and Crippled.

FIG. 63.—VENTRAL HERNIA.

Symptoms.—In many cases there are practically no symptoms, while in others the symptoms appear more severe than might be expected from so small a hernia. Nausea and vomiting, discomfort, dull dragging pains in the epigastrium, are the most common symptoms.

Treatment.—While some authorities (Macready) state that epigas-

tric hernias are best treated with an umbilical truss, others, including Graser, say that trusses are generally useless, and a small epigastric hernia in itself is perfectly harmless. There is no chance of effecting a cure of an epigastric hernia by mechanical treatment, and while the danger of strangulation in this type of hernia is not great, there is a practical certainty that the hernia will increase in size and will prove a source of greater and greater annoyance and discomfort. For these reasons I believe a radical operation is indicated in all cases in which there are no contraindications. The type of operation to be recommended is the Mayo operation for umbilical hernia. The results of this operation for epigastric hernia observed at the Hospital for Ruptured and Crippled have thus far been perfect.

Hernia at the outer border of the rectus muscle (hernia linea semilunaris) has been described by Macready and others. This hernia is very rare. It may occur in children, but is most often seen in adults. It has sometimes been grouped with lumbar hernia; it is most often seen below the umbilicus and near the pubis. Macready found only 14 such cases in the surgical literature and 9 in the records of the London Truss Society during a period of twenty years.

Ventral Hernia Following Laparotomy.—Hernias following abdominal section are far less frequently found than a decade or more ago, when the technic of closing the abdominal wall was less perfect. At the Hospital for Ruptured and Crippled 200 cases of ventral hernia have been observed within ten years. The size of the hernia varies from that of a walnut, to almost complete eventration.

A study of the methods of closure of the abdominal wall shows a greater proportion of hernias following a single through-and-through suture of the abdominal wall than closure by means of separate layers. Abel states that of 586 patients examined after abdominal section, 20 per cent. showed a hernia following single layer suture, while only 9 per cent. were found after suture in separate layers.

Noble,[52] of Philadelphia, has applied Championnière's method of overlapping the fascia in inguinal hernia to all operations for abdominal section, and states that in the last five years he has not had a hernia following abdominal section.

In addition to the method of closure, the nature of the wound healing has an important bearing upon the subsequent development of a hernia. Abel states that in cases in which suppuration lasted two weeks, a hernia followed in 40 per cent.; when it lasted three weeks, a hernia followed in 50 per cent.; and after four weeks' suppuration a hernia developed in 65 per cent.; cases with over four weeks' suppuration showed a hernia in 80 per cent. Of the suppurative cases, those sutured by the through-and-through method showed twice as great a tendency to the formation of a hernia as those sutured in separate layers.

The symptoms associated with ventral hernia following laparotomy are not unlike those seen in umbilical hernia in general; they are apt to be, however, more severe, for the reason that the adhesions are often

greater. The covering of the hernia is usually the thinned-out cicatrix instead of skin; hence it is far more liable to ulcerate.

Treatment.—In children and young adults in good health operation should be performed by applying the principle of overlapping the fascia. Very large hernias may be permanently cured by this operation. It is wise to make the incision a little to the outer border of the scar in order to avoid wounding the intestine and omentum, which are usually adherent to the scar. The entire scar should always be removed.

DIAPHRAGMATIC HERNIA.

This term has usually been employed in its widest sense, to include not only the true hernias through the diaphragm, but false hernias as well. A true diaphragmatic hernia always has a sac, and may be either congenital or acquired. The condition is comparatively rare. The largest collection of cases (Grosser and Thoma[53]) contained 433 cases, 232 of which were congenital, 181 acquired. Of the congenital hernias, 30 only were true hernias; and of the acquired, 10. This variety of hernia is more frequently found on the left than on the right side, in the proportion of 2 to 1 in the true, and 6 to 1 in the false hernias. This greater frequency on the left side is partly explained by the position of the liver on the right side, which acts as a barrier, protecting the diaphragm, and partly by the fact that in traumatic direct hernia, especially from stab wounds, the wounds are more frequently found upon the left side of the abdomen.

FIG. 64.—A NEWBORN CHILD WITH A TRUE LEFT-SIDED CONGENITAL DIAPHRAGMATIC HERNIA (Sultan).

Although the diagnosis has been made in only six instances, there are certain fairly characteristic signs which should make one suspect the

existence of a diaphragmatic hernia. The most important physical sign is dextra cardia, or displacement of the heart to the right side. Another sign is an area of tympanitic resonance over the thorax. This area is apt to vary in size at different times. As the stomach is often found to be the contents of a diaphragmatic hernia, the injection of bismuth into the stomach, and then taking an *x*-ray photograph, will show the abnormal position of the organ. Digestive disturbances, gastric pain, and nausea are often present. These symptoms frequently come on suddenly and vary greatly in intensity. In cases of traumatic origin, in which the hernia develops suddenly, the symptoms may be very severe, depending upon the amount of intestine forced into the thoracic cavity. In some instances there may be very great dyspnea and cyanosis. Occasionally, especially in the new-born, the entire contents of the abdomen is found in the thoracic cavity. In many cases of injury to the diaphragm, especially stab and gunshot wounds, the tumor does not develop until some time after the injury. Of 36 cases of injury to the diaphragm collected by Loscher,[54] 21 died of diaphragmatic hernia, 5 the first day, 10 the first month, 5 within five years, and 5 in twenty years.

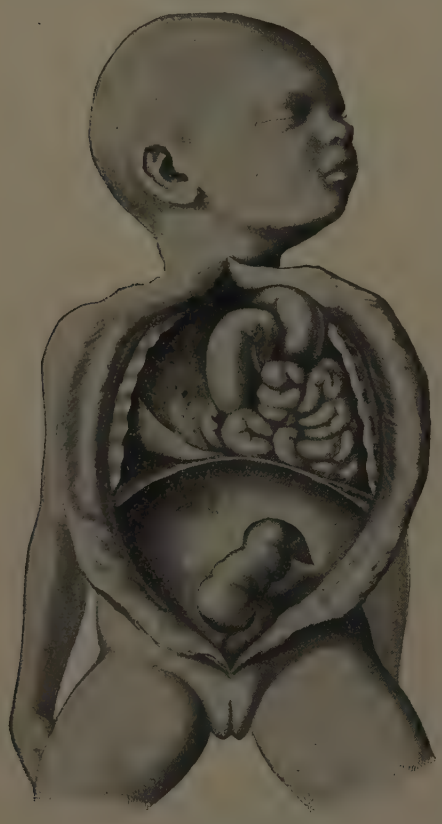

FIG. 65.—A NEWBORN CHILD WITH A FALSE LEFT-SIDED CONGENITAL DIAPHRAGMATIC HERNIA (Sultan).

Treatment.—Rydygier advises an osteoplastic flap of the ribs, cutting them externally and using the sternocostal articulation as a hinge. This would be impossible in adults. Resection of the ribs is preferable in most cases. Suture of the opening of the diaphragm is difficult, and sutures, when put in, are apt to tear out. Some surgeons have advised sewing the stomach into the hernial orifice. If the diagnosis of strangulated diaphragmatic hernia is made, it is better to first do a laparotomy and try to reduce the contents of the hernia into the abdominal cavity by traction, and, if successful, then to attempt to close the opening. If unsuccessful, it may be wise to resect the ribs and approach the hernia from the thoracic side. Most of the methods hitherto proposed have

been recommended solely on theoretic grounds, and thus far have received no practical test of their efficiency.

According to Benno-Schmidt, 15 per cent. of all cases of diaphragmatic hernia have died of incarceration. Nevertheless Martin, in 1904, was able to collect but 15 operations for incarcerated hernia, which number included one of his own cases. Vayhinger[55] collected 77 cases of diaphragmatic hernia treated by operation; 52. of these were free hernias, 25 incarcerated. To the latter he adds one case recently operated upon at v. Bruns' clinic. In 8 of the incarcerated cases the diagnosis was made only at autopsy. Methling in a recent publication speaks of but one operative cure of an incarcerated diaphragmatic hernia.

According to Vayhinger's table, 10 of the 26 cases of incarcerated diaphragmatic hernia operated upon were of congenital, 16 of traumatic, origin.

In 10 instances the diagnosis was made before operation, in 8 during and in 8 after operation.

An abdominal operation was performed in 22 cases; 4 were operated upon transpleurally. Only 6 of the entire number were cured; 20 resulted fatally.

Of the cases in which the diagnosis was made before operation, 3 were operated upon by the transpleural route (2 cures and 1 death), 7 by laparotomy (3 cures and 4 deaths very soon after operation).

Vayhinger believes the transpleural method decidedly superior to abdominal laparotomy.

HERNIA OF THE STOMACH.

This is usually a type of diaphragmatic hernia in which the stomach happens to form a portion or all of the contents of the hernia. In exceedingly rare cases the stomach has been found in the contents of an inguinal or femoral hernia; also in congenital hernia of the cord and in post-operative ventral hernia.

Of 63 cases collected by Knaggs,[56] 34 were congenital. The next in order of frequency is the traumatic variety, 21 cases, of which 7 were due to stab wounds, 7 to contusions, 6 to falls, and 1 to the patient's being run over. Acquired diaphragmatic hernias are the least common of the three varieties, only 8 cases being reported by Knaggs. This type of hernia is much more chronic in its course; it may be distinguished from the other two varieties by the presence of a sac. Of the 8 cases collected by Knaggs, 3 were on the right, 4 on the left side, and 1 on both sides of the thorax. In 3 cases the hernia protruded through a dilated esophageal opening. According to Knaggs, the stomach formed the contents of the sac in only 9 cases; stomach and part of jejunum in 3 cases; stomach and omentum in 5 cases; stomach and spleen in 3 cases; stomach, spleen, pancreas, and colon in 5 cases; stomach, spleen, and transverse colon in 6 cases; stomach and colon in 22 cases; stomach, liver, and small intestine in 3 cases; stomach, spleen, liver, omentum, and small intestine in 2 cases; almost all abdominal viscera in 1 case.

OBTURATOR HERNIA.

This form of hernia was first described by Arnaud de Ronsel, in 1720. This condition is extremely rare, only 200 cases having been reported. The diagnosis has rarely been made until strangulation had occurred, and even then the true condition has not been made out until after operation had been performed on the supposition that the patient was suffering from intestinal obstruction of unknown origin.

Berger found only one case in 10,000 hernias observed at the Société des Bandages, in Paris, while at the Hospital for Ruptured and Crippled not a single case has been noted in upward of 75,000 cases observed since 1890. The fact that this variety is so seldom recognized is due to the anatomic difficulties associated with the condition. Fig. 66 shows the obturator opening covered with a thin membrane of fascia in which there is a cleft or opening for the passage of the nerves and vessels. On the inner or pelvic side the foramen is covered with the obturator internus,

while more externally are situated the obturator externus and pectineus muscle. Hence, the hernia must first push in front or to one side these muscular structures before it forms a tumor of sufficient size to be palpated externally.

Diagnosis.—The only symptom of value in cases that have not become strangulated is the so-called Howship-Romberg symptom, which consists in pain and sensory disturbance along the inner side of the thigh, and due to the pressure of the hernial tumor upon the obturator nerve. The obturator nerve supplies the adductor longus and brevis muscle as well as the gracilis, and also distributes its sensory fibers to the inner side of the thigh as far down as the knee. In cases in which the hernia has attained sufficient size, there may be a slight fullness observed a little below, to the inner side of the femoral ring or in the region of the pectineus muscle. This is more easily recognized by flexing the leg and thigh.

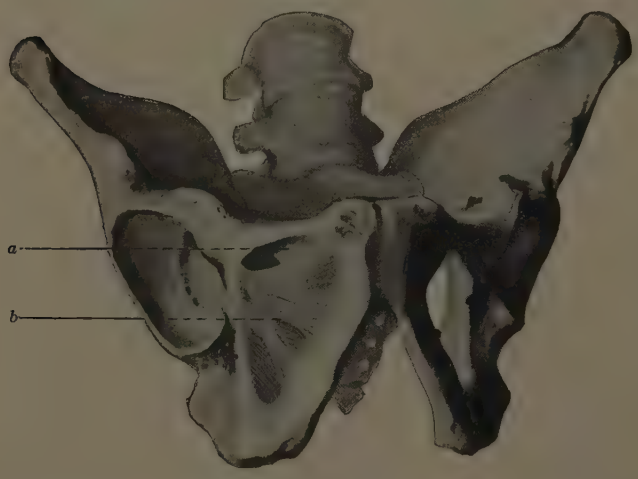

FIG. 66.

A bony pelvis in which the obturator membrane (*b*) has been left in the right obturator foramen. The membrane entirely fills the foramen, with the exception of an opening (*a*) which is designated as the obturator canal. It is through this opening that the obturator hernia escapes, the obturator vessels and nerve being pushed to one side (Sultan).

Treatment.—In view of the fact that the diagnosis of obturator hernia is seldom made until strangulation has developed, the treatment is limited practically to this condition. It is wise to first make an incision in the femoral region and attempt to reduce the hernia by slightly enlarging the obturator opening. This must be done with extreme care, and the nicking or cutting of the opening should be made in an upward and inward direction to avoid injury to the obturator vessels which usually lie just to the outer side of the sac. In cases in which resection is necessary, it is better to do a median abdominal section, and after carefully protecting the rest of the abdominal cavity with sterile gauze, to then by gentle traction draw out the strangulated loop of bowel. Primary resection can now be performed under much more favorable conditions than through the femoral opening. The hernial sac should be removed if possible and the ring closed by chromicized kangaroo tendon or catgut.

In some cases it might be wise to use the osteoplastic flap method originally proposed by Trendelenburg and Kraske, in 1891, for large

femoral and some cases of inguinal hernia, and recently employed in obturator hernia by Schwartzschild.[57] Schwartzschild has lately used this method in a case of obturator hernia, strangulated for the third time, and relieved on the two previous occasions by abdominal section. In this case there were absolutely no symptoms diagnostic of obturator hernia and the case was operated upon as one of intestinal strangulation. In view of the previous history of recurrence, Schwartzschild decided to attempt a more radical method of closure. A periosteal bone flap 4 cm. wide was chiseled from the inner side of the symphysis pubis and the descending ramus, and placed directly over the hernial opening. This periosteal bone flap was fastened to the muscular structures by means of catgut sutures and the pectineus was then sutured over the same; finally the fascia, muscle, and skin were united in separate layers. The patient made an uninterrupted recovery.

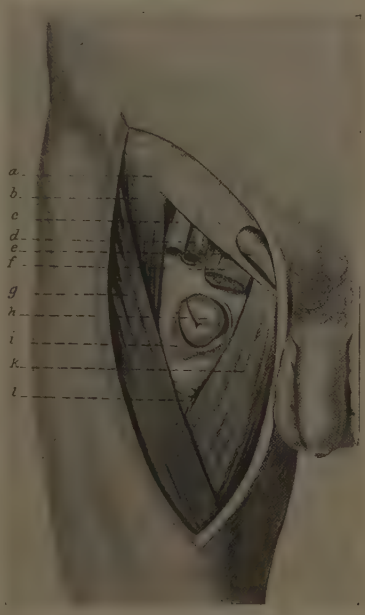

FIG. 67.—ANTERIOR VIEW OF AN OBTURATOR HERNIA (Sultan).

A part of the pectineus and the entire obturator externus muscle have been removed, exposing the bony pelvis and a portion of the obturator membrane. The iliopsoas and pectineus muscles have been drawn apart, and between them lie the stumps of the femoral vessels. The sac of the obturator hernia has been opened and an intestinal coil is seen within. *a*, Poupart's ligament; *b*, iliopsoas muscle; *c*, femoral artery; *d*, femoral vein; *e*, spermatic cord; *f*, upper stump of the pectineus muscle; *g*, sartorius muscle; *h*, obturator hernia; *i*, obturator membrane; *k*, adductor longus; *l*, lower stump of the pectineus muscle.

Schwartzschild strongly recommends this method of operation in all cases in which the diagnosis of obturator hernia is made and the patient's condition warrants it. Of 21 cases collected from the literature, treated by laparotomy, 9 were successful, or 42.85 per cent. In view of the comparative frequency of relapse, radical operation should always be performed when possible. In 105 cases of obturator hernia collected by Schwartzschild no operation was performed in 62 cases; of 43 cases operated upon, 17 were cured. The method of operation in the cured cases was: femoral incision in 13; laparotomy in 3; a combination of both methods in one. An artificial anus was established in 4 with 4 deaths; intestinal resection was done in 5 cases with 1 recovery.

With regard to the diagnosis of obturator hernia, he points out the great difficulties and states that even Howship-Romberg's sign cannot be relied upon, as it has been observed in other conditions as well. Hence, its presence does not invariably prove the existence of an obturator hernia, any more than its absence precludes the possibility of the presence of such hernia. He cites several instances in which this sign has led to errors in diagnosis.

SCIATIC HERNIA (GLUTEAL, ISCHIATIC).

This is one of the rarest varieties of hernia observed, only 11 cases having been collected by Garrè up to 1892. Another case has recently been reported by von Eiselsberg.[59] The hernia may find its exit through either the greater or the lesser sciatic foramen. Garrè would classify all hernias passing through the lesser sciatic foramen as sciatic hernias, and those passing through the greater sciatic foramen as gluteal hernias, still further subdividing the latter into superior and inferior gluteal hernias, according as the hernial sac passes above or below the pyriformis muscle, which nearly fills this foramen. The superior gluteal variety has been observed most frequently (Fig. 68).

FIG. 68.—A LATERAL VIEW OF A SCIATIC HERNIA (SUPERIOR GLUTEAL HERNIA) (Sultan).

These hernias appear externally above the border of the gluteus maximus and it may be very difficult to differentiate them from perineal hernias. They are usually of small size, though some cases have been observed in which the tumor was as large as a child's head. They may also be mistaken for teratoma, lipoma, spina bifida. Von Eiselsberg's case was associated with a lipoma and had apparently once been strangulated. A portion of the intestine had sloughed off and the lumen had evidently been reestablished by nature within the hernial ring.

Treatment.—The diagnosis has seldom been made, and the cases reported are so few in number that no definite mode of procedure has yet been established. When operating upon a tumor in the gluteal region, the possibility of a hernia should always be considered, and if there is an im-

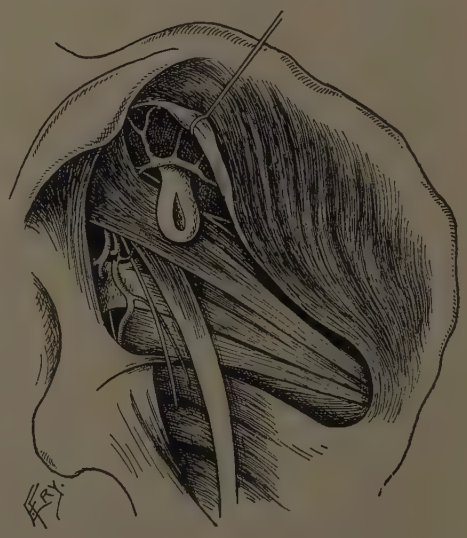

FIG. 69.—ISCHIATIC HERNIA (Garrè).

pulse on coughing, and resonance on percussion, one can be certain of a hernia. In view of the frequency of strangulation in these cases, it would seem wise, if the diagnosis is made in reducible cases, to operate and attempt to close the opening of muscle and fascia, remembering that the sciatic and gluteal arteries are in close proximity to the ring and could be easily wounded. If the hernia is strangulated when discovered, then the combined operation will probably give best results: First, the external incision opening the sac and evacuating the possibly already infected fluid exudate; then the median abdominal incision and attempt to reduce the strangulated loop by traction. If gangrene is already present, resection can be performed far more easily and safely than through the external incision.

INTERNAL HERNIA.

Under this heading are grouped the several varieties of retroperitoneal hernia and hernia of the foramen of Winslow.

Retroperitoneal hernia occurs in the various fossæ which are found more or less constantly in certain regions of the peritoneal cavity. Moynihan's[27] work upon the anatomy and surgery of the peritoneal fossæ furnishes us the most complete data upon the subject of internal hernia. He describes nine separate fossæ which may be the cause of retroperitoneal hernia. Of these, only five are of much practical importance, the remainder being very rarely found. The five more important fossæ are: (1) The superior duodenal fossa; (2) the inferior duodenal fossa of Treitz; (3) the paraduodenal fossa (Landzert); (4) the mesenterico-parietal fossa (Waldeyer); (5) the mesocolic fossa.

The superior duodenal fossa is found in 40 to 50 per cent. of the cases. It was first described by Brösike, and occupies the upper horn of the fossa of Treitz.

The inferior duodenal fossa is the most frequent of all peritoneal fossæ and has been found in 70 to 75 per cent. of the cases. It is situated on the left side of the ascending portion of the duodenum, opposite the third lumbar vertebra, according to Moynihan, and the orifice looks almost directly upward or slightly to one side, being opposite the orifice of the superior duodenal fossa, which looks downward.

The paraduodenal fossa (Landzert) is situated to the left and some distance from the ascending limb of the duodenum. The fossa is caused by the raising up of a peritoneal fold by the inferior mesenteric vein. "The sac is bounded by the parietal peritoneum, covering the psoas, the renal vessels, the ureter, and a portion of the left kidney. The orifice of the sac is wide and looks downward to the right."

The Mesenterico-parietal Fossa.—This fossa is usually found in the first part of the mesojejunum, immediately behind the superior mesenteric artery, and below the duodenum. Moynihan has found this fossa present three times in adults; in seventeen embryos of less than five or six months it was present in six.

The mesocolic fossa is formed by a fold containing the ascending branch

of the left colic artery. It extends between the layers of the transverse mesocolon toward the splenic flexure.

Moynihan believes that the etiology of peritoneal fossæ is best explained by regarding them as fusion folds between the original left, afterward anterior, surface of the ascending portion of the duodenum and the right or anterior surface of the descending mescolon folds, which date their origin from the time when these two peritoneal surfaces are in close apposition, namely, at the end of the third or the beginning of the fourth month.

Treitz[60] (in 1857) was the first to call attention to internal hernia, and

Fig. 70.—1, Duodenojejunal Fossa; 2, Intersigmoid Fossa (Sultan).

his careful study of the various fossæ represents the first attempt at a scientific explanation of their etiology. As Moynihan states, before the time of Treitz the subject of retroperitoneal hernia did not exist. It was he who first recognized that such hernias occur in fossæ which are normal, and it was he who first gave an intelligent description of their probable mode of development.

Duodenal hernia may be divided into left and right, the left being the more common. Left duodenal hernia probably originates in nearly every case in the paraduodenal fossa, or fossa of Landzert. Essential to

the formation of such a hernia, according to Treitz, are: (1) The existence of a fossa and its boundary fold; (2) the presence of the inferior mesenteric vein in the fold; (3) sufficient mobility of the small intestine to permit its entering the hernial sac.

The average size of the mouth of the sac in the cases of left duodenal hernia thus far observed has been 2 to 3 inches. The size of the hernia varies greatly, ranging between the size of an English walnut and a man's

FIG. 71.—HERNIA DUODENOJEJUNALIS (Sultan, after Aschoff). NON-STRANGULATED CASES.

head. In some cases almost the entire intestine, large and small, is present.

Moynihan, up to 1897, collected 57 cases of left duodenal hernia. Since this time a number of new cases have been added.

Right Duodenal Hernia.—In the early stage of development right duodenal hernia is found in the right half of the abdominal cavity; later on, it may extend into the left portion. According to Brösike, the condition essential to its development is an abnormal fusion of the upper portion of the jejunum to the posterior abdominal wall. As a result of the fusion an opening occurs in the mesentery, which finally becomes a fossa, from which the hernia develops.

According to Moynihan, the predisposing causes of right duodenal hernia are: (1) a hernial sac lying behind the ascending and transverse

mesocolon; (2) the orifice situated behind and to the left of the sac; (3) the presence of the superior mesenteric artery in the anterior margin of the sac.

Seventeen cases of right duodenal hernia have been collected by Moynihan; the first case being that of Klob, in 1861, the last that of Paton, in 1906.

Mesocolic hernias and hernias of the infraduodenal fossa are too rare to be more than mentioned.

Diagnosis.—The diagnosis of duodenal hernia has rarely been made, except at autopsy or during operation for acute intestinal obstruction of unknown origin. A careful study of the reported cases, however, shows certain features which, in the opinion of Moynihan, should enable the surgeon to make a correct diagnosis, at least in a certain proportion of cases. First, the tumor is limited to a certain definite area of the abdominal cavity. In left duodenal hernia this tumor will, in the beginning, occupy the left and upper portion of the abdomen; in right duodenal hernia, the right and upper portion; but in both cases the tumor gradually increases in size until it finally occupies nearly the entire cavity. Such a tumor can usually be distinctly outlined on palpation and is always resonant. Auscultation reveals a distinct gurgling sound over the entire tumor area.

Symptomatology.—The symptoms vary widely. In the majority of the cases in which the tumor has developed very gradually there will be found a history of chronic indigestion; in those cases in which the hernia has developed very suddenly or become suddenly very much larger, the symptoms may be those of acute intestinal obstruction.

Treatment.—Up to the present time operative treatment only can be considered in such cases in which symptoms of obstruction have developed. Thus far ten successful cases have been recorded, nine of left and one of right duodenal hernia. In most cases the strangulated loop of bowel can be drawn out by gentle traction. In cases in which this is impossible, very little can be done, inasmuch as an attempt to enlarge the opening by incision would result in division of the inferior mesenteric vein. In such cases Moynihan recommends entering the sac through an incision from the outer side of the vein, drawing the distended intestine through this opening, emptying it of its contents by means of one or more incisions, after closing which the loop is replaced in the original sac. The distention having been relieved by this procedure, the loop can then be readily withdrawn through the neck of the sac into the abdominal cavity. Even after reduction has been successfully accomplished it is a very difficult matter to close the hernial opening in such a way as to prevent a redevelopment of the hernia. Lawford Knaggs[56] in a case of inflamed duodenal hernia partially closed the hernial opening by continuous suture applied to the inside of the sac through the edges of the opening. The edges of the incision through the anterior wall of the sac were then attached to the upper angle of the parietal wound and the interior of the sac was finally packed with gauze. The patient was discharged well at the end of seven weeks, but died seven months later with an attack

of typhoid fever. Autopsy, which was obtained, showed the manner in which the hernial opening had been obliterated.

Pericecal Hernia.—Several fossæ have been discovered in the region of the cecum. The first description of such fossæ is that of Santorini, in 1775. Waldeyer, in 1868, described four fossæ in this region.

These fossæ are described at much length by Moynihan,[29] who has collected seven cases of pericecal hernia. The condition is very rare.

Symptoms.—There are no symptoms of pericecal hernia until strangulation occurs. In some cases the history very closely resembles that of chronic appendicitis. Usually, however, the symptoms are typical of acute intestinal obstruction. In some cases a tumor may be felt in the right iliac fossa.

In all of the seven cases collected by Moynihan operation was done, with a mortality of 50 per cent. In view of the fact that two of the deaths were due to inhalation pneumonia, the importance of washing out the stomach in cases of such obstruction is emphasized by Moynihan.

Paraduodenal Hernia.—According to Treitz, these hernias are always acquired, being caused by violent effort, such as a blow, shock, or concussion. In all such cases, however, there exists a predisposing cause, *e. g.*, the presence of a large or deep fossa, elasticity of the retroperitoneal cellular tissue, and great emaciation of the subject.

On the other hand, Landzert believes that these hernias are nearly always congenital. The clinical picture is seldom characteristic. In the early stages there are no phenomena of note, while later on, as partial occlusion develops, symptoms of digestive disturbance occur; constipation, pains after eating, epigastric cramps, eructations; occasionally there is biliary vomiting after eating. At the time when such symptoms have become well pronounced, there will usually be found a tumor above the umbilicus. In some cases there are symptoms of slow strangulation, preceded by separate crises or by single and prolonged crisis. Acute strangulation is rare in duodenal hernia. Although Jonnesco has reported seven cases, Narath, in 1903, was able to find only eight cases of duodenal hernia treated by operation. In 1906 Vautrin[61] collected 14 cases. Only four cases of cures have been reported to date.

Hernia through the Foramen of Winslow.—The first case of this kind was published by Blandin in 1823 and found at autopsy. Rokitansky reported a second case in 1842, Treitz a third in 1857, Wilson Moir a fourth in 1867, and Majoli a fifth in 1884.

This subject has been exhaustively treated by Moynihan (*loc. cit.*), but more recently, in 1906, by Jeanbrau and Riche.[62] Up to the present time 20 cases have been recorded. Of the 16 cases in which the sex was known, 13 were men, 3 women; the youngest was eight years, the oldest seventy-seven. In the opinion of Jeanbrau and Riche, hernia in the foramen of Winslow is usually the result of some violent effort which causes a portion of the small or large intestine to be pushed through the foramen of Winslow into the lesser peritoneal cavity. The causes as tabulated by Moynihan are: (1) A common mesentery for the whole intestine; (2) absence of the secondary fusion of the ascending colon to the posterior abdominal wall; (3) abnormally large size of the foramen of Winslow; (4) abnormal length of the mesentery, giving rise to undue mobility of the intestine.

Symptomatology.—In 9 out of 12 cases collected by Jeanbrau and

Riche there was an epigastric or periumbilical tumefaction. The exact clinical diagnosis has thus far never been made. In 13 cases in which strangulation was especially noted, a constriction of the borders of the foramen of Winslow was observed 11 times. In the cases thus far recorded the more pronounced symptoms have been epigastric pain in the region of the umbilicus or just above it; an epigastric tumor is present in most cases, such tumor being dull on light percussion, but resonant on deep percussion.

Treatment.—In 11 of the 18 cases collected by Jeanbrau and Riche laparatomy was performed, with 4 cures. The only contraindications to operation are (1) insufficient knowledge on the part of the surgeon to perform such a difficult operation; (2) the weak condition of the patient.

The treatment should consist in a median abdominal incision sufficiently long to facilitate proper exploration. The diagnosis having been established, an attempt should be made to reduce the hernia by simple traction; in the event of failure to reduce the bowel, the enlargement of the foramen of Winslow by various methods has been advocated. Jeanbrau and Riche, after a series of experiments upon the cadaver, believe that the foramen can be safely enlarged by an incision made through the peritoneum forming the anterior lamina of the gastrohepatic omentum at the upper border of the first part of the duodenum. Their method is practically the technic employed by Wiart for the exposure of the common duct. This procedure, while comparatively easy upon the cadaver, in the opinion of Moynihan is quite impossible on the living subject. Moynihan considers it much wiser to enter the lesser peritoneal sac by making an opening through the gastrohepatic or gastrocolic omentum. The distended coils may then be incised and emptied of their contents and the incisions closed. In this way it is probable that the hernia may be reduced by traction without enlarging the foramen of Winslow.

Hernia of the Intersigmoid Fossa.—According to Moynihan, there are only two authentic cases of hernia of the intersigmoid fossa on record, namely, the case of Eve's[63] and that of MacAdam Eccles.[64] To these I am able to add the following personal case:

On September 8, 1907, a case of congenital retroperitoneal hernia of the intersigmoid fossa, in an infant three days old, came under my observation. The only unusual thing noticed the first twenty-four hours was the fact that the child cried almost constantly, occasionally spitting up a little mucus. He had two or three meconium stools, but no satisfactory bowel movements afterward. On the third day the infant developed signs of intestinal obstruction and died seventy-four hours after birth. No distinct tumor could be made out prior to death, although on the second and third days the nurse thought the abdomen was larger and harder on the left side. A catheter could not be made to pass over 3 inches into the rectum. Autopsy made two hours after death showed a semilunar opening one and one half inches long at the site of the intersigmoid fossa, through which almost the entire intestine had passed, forming a large retroperitoneal hernia extending up nearly to the costal arch, and occupying the left side of the abdomen. The hernia was

gangrenous and the entire contents of the intestine were found in the abdominal cavity. The case will be reported more at length elsewhere.

LUMBAR HERNIA.

While many writers have included under lumbar hernia cases of traumatic origin and cases resulting from suppuration or Pott's disease, especially caries of the spine, such cases should properly be excluded, and only those cases considered which are of spontaneous and congenital origin. By lumbar hernia is meant a hernia which appears in the lateral region of the abdomen between the crest of the ilium and the costal arch. Such hernias have been supposed to find their exit through the triangle

FIG. 72.—CONGENITAL LUMBAR HERNIA (Dowd).

A, Transversalis fascia; *B*, external oblique muscle; *c*, latissimus dorsi muscle; *D*, crest of ilium; *E*, gluteus maximus muscle; *F*, gluteus medius muscle.

FIG. 73.—DOWD'S OPERATION FOR THE CURE OF CONGENITAL LUMBAR HERNIA.

Flap composed of fascia, lata and aponeurotic part of gluteus maximus and medius. Stitches placed for suturing this flap to the lumbar fascia, to the external oblique muscle and to the latissimus dorsi muscle and for drawing the upper parts of the latissimus dorsi and external oblique together.

of Petit, which is bounded below by the crest of the ilium, anteriorly by the external oblique, and posteriorly by the outer edge of the latissimus dorsi muscles.

Braun[65] in 1879 collected twenty-six cases of supposed lumbar hernia, but six should be excluded as of traumatic or inflammatory origin. Braun, and later Grange and Besendonk, attempted to prove that few of the cases of lumbar hernia, if any, show any accurate anatomic evidence of having found their exit at the triangle of Petit, and Sultan (1902) states that "post-mortem examinations and exact dissections have never yet proved that Petit's triangle formed the hernial orifice in any case." This statement no longer holds true, as Dowd's[66] case gives an accurate description of the hernial orifice, and there is no doubt that it occupied the triangle of Petit. In the case of Bull, operated ten years ago at the Hospital for Ruptured and Crippled, the hernia also came through the

triangle of Petit. Sultan, in 1902, stated that there are only two known instances of operation for non-strangulated lumbar hernia. Dowd's case and Bull's added would make four. Four cases collected by Macready (London Truss Society), added to those collected by Braun, give a total of twenty-eight.

The diagnosis of lumbar hernia is not difficult. There is a marked impulse and increase in size on coughing, and resonance on percussion and often a gurgling sound on reduction. In rare cases the hernial tumor has become strangulated.

Treatment.—The only treatment that is advised by Macready is a spring-truss with a pad made to fit the opening. Sultan states that the only two cases of non-strangulated lumbar hernia operated upon up to 1902 were the cases of Owen, who closed the wound with catgut, and Küster, who closed it with a skin muscle bone-flap. In the case operated

FIG. 74.—DOWD'S OPERATION FOR THE CURE OF CONGENITAL LUMBAR HERNIA.
Stitches tied, leaving a triangular defect above the flap.

FIG. 75.—DOWD'S OPERATION FOR THE CURE OF CONGENITAL LUMBAR HERNIA.
Triangular defect and sutured area covered in by a flap from the aponeurosis of the latissimus dorsi muscle.

upon by Bull at the Hospital for Ruptured and Crippled, in 1896, the wound was closed by overlapping the muscle and fascia with kangaroo tendon. The patient made a good recovery and is still well without recurrence, ten years later. Dowd devised a more elaborate muscle flap operation (Figs. 72–75). The result in his case, up to the time of last observation, was perfect.

I believe that all of these cases can be cured by operation, and operative treatment should be advocated in preference to mechanical means.

Wm. M. Mastin, of Mobile, Ala., has observed a case of lumbar hernia associated with very marked scoliosis (Fig. 76) which, in his opinion, was an important factor in the etiology. Berger has noted a similar case. I believe it much more probable, however, that the curvature of the spine in these cases was a coincidence, rather than a causative factor in the production of the hernia.

PERINEAL HERNIA, OR HERNIA THROUGH THE PELVIC OUTLET.

The outlet of the pelvis is so strongly protected by a lining of muscles and fascia (the levator ani and coccygeal muscles and pelvic fascia) that a hernia very seldom occurs. These perineal hernias are subdivided according to their several sites of exit. In the male the hernial tumor is usually found in the perineum and is often described as an ischiorectal hernia or perineal hernia. In the female the hernia may pass through the pelvic fascia in front of or behind the uterus and broad ligaments. When it passes behind, it appears, as in the male, in the perineal region. More often it passes out in front of the broad ligament and appears externally in the labium majus, often resembling an inguinolabial hernia, except for the fact that the external ring is empty. Sometimes the hernia passes into the rectum, and as it advances it pushes the rectum along with it, causing a prolapse in addition to the hernia. The hernia usually appears on one side, rather than in the middle line, and shows itself externally, just below the border of the gluteus maximus muscle, closely resembling sciatic hernia.

FIG. 76.—LUMBAR HERNIA WITH SPINAL CURVATURE (Mastin).

Etiology.—The principal cause of perineal hernia, according to Ebner's investigations (Macready), is some congenital abnormality in the parietal peritoneum, which extends lower down than usual, especially in the region of Douglas' pouch. Ebner made a study of 60 bodies and found that in 25 there existed gaps between the coccygeus and ischiococcygeus muscles. Such gaps, while they would probably favor the development of a perineal hernia, are probably of less importance as an etiologic factor than the peritoneal abnormality. Of 40 cases of hernia of the pelvic outlet collected by Macready, 6 occurred in males, 34 in females, and all in adults. The intestine, bladder, ovary, and rectum may form the contents of the sac.

The diagnosis is not difficult in the male, though in the female the condition has been mistaken for vaginal cyst, with most serious results. In one case a loop of bowel several inches in length was cut off; in another, reported by Ganz, the hernia was incised on the supposition that it was a cyst, and the cecum, which afterward protruded, became gangrenous and caused the death of the patient.

When the hernia appears in the vagina (vaginal hernia), it is covered

with a mucous membrane and may be mistaken for a uterine polyp, especially as the hernia may find its exit near the cervix.

Michaelson and Lukin[67] report a case of the Kronstadt Hospital in which a supposed uterine polyp was amputated. The patient died the following day and the autopsy showed that about 5 inches of the transverse colon and a foot of omentum had been excised.

The hernia may appear in the ischiorectal fossa, and here usually attains a larger size than the ordinary hernia of the pelvic outlet. Papen's celebrated case (1755), quoted by Macready, extended to the calves of the leg and contained practically all of the abdominal viscera.

Treatment.—In certain cases some form of mechanical support, constructed after the style of a pessary, may retain the hernia fairly well. In most cases, however, it is difficult or impossible to control the hernia. Winckel advocates operation in all cases in the female. T. Gaillard Thomas advised inverting the sac from below like the finger of a glove and suturing of the inverted sac to the abdominal wall. When associated with prolapse of the rectum the operation recommended by Mikulicz, of resecting the prolapsed portion of the rectum and uniting the proximal part to the anus, may be performed. Very few cases of operation for hernia of the pelvic outlet have thus far been recorded, and it is impossible to lay down any definite rules as to operative procedures.

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CHAPTER LIV.

SURGERY OF THE RECTUM AND ANUS.

By Robert Abbe, M.D.,
NEW YORK.

Anatomy.—The region of the rectum and anus presents many anatomic, physiologic, and pathologic considerations which need to be understood before successful results of surgical work can be accomplished. Here, as in other portions of the alimentary tract, notably the mouth, it is difficult to obtain an operative field free from infection, and experience of nature's reparative power in the presence of contamination is a necessary part of one's calculation in estimating the outcome of rectopelvic work.

Contaminations of the peritoneum, of the ischiorectal cellular planes, of the bladder, are often inevitable, and must be reckoned with as serious complications unless under vigilant guard and correction before, during, and after operation. To know simply the anatomy of the parts and possible operative methods will not give adequate insurance of the patient's life.

It is often more important to realize that wounds of this region are safely and firmly closed by cicatricial healing when packed with gauze and left to granulation, thus saving much time at operation, and draining safely a region in which much danger lurks if infecting fluids are confined. With proper respect to this and other considerations to be treated of later, there is no reason why operations should not be as safely conducted here as elsewhere.

From a surgical point of view, the gross anatomy of the rectum must be seen as well from the aspect presented to the surgeon's eye when he looks into the open peritoneal cavity from above, as from the dissection of the pelvis.

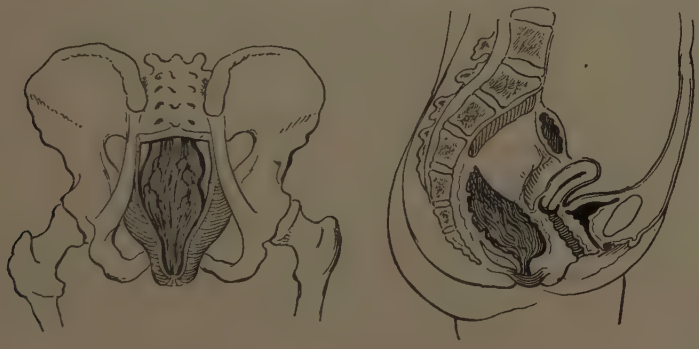
When the patient is in the Trendelenburg posture and all movable intestines are raised from the pelvis and kept well up in the abdominal cavity, there remain the lower part of the sigmoid colon, and the rectum, alone visible. These are held against the hollow of the sacrum, loosely above by the mesenteric attachment, and firmly below where the peritoneum spreads out over the sides and front of the rectum.

At the upper two segments of the sacrum the mesentery is narrow and median, containing blood-vessels and lymphatics. Here the sigmoid ends and the rectum begins. On either side of the pelvis the peritoneum is loosely attached over the iliac vessels and the ureter, as also on the sides of the rectum, but on the anterior aspect it is much more tightly adherent.

From within, the fingers pressing down on the bottom of the pelvic cul-de-sac find a resisting floor, the pelvic diaphragm, so called, which is mainly supported by the levator ani muscles—widely attached to the pelvic fascia on both sides and fixed in the median line from the tip of the coccyx to the perineal body. This, with the accompanying pelvic fascia, is what is torn more or less severely in lacerations of the female perineum at parturition, and which in surgical operation for removal of the rectum must be cut through before the rectum can be excised.

When the finger is pressed in the cul-de-sac in front of the rectum in the female pelvis, it is in contact with the posterior vaginal wall in front, for the space of the upper one-fifth of the vagina. Otherwise no viscus is touched. But in the male, pressure at the same point feels the triangular space at the base of the bladder and touches the prostate and seminal vesicles.

The **blood-supply** of the rectum is of much practical importance. Three arteries share in the supply. From above, the superior hemor-



a *b*

FIG. 77.—*a*. Rectum shown through divided levatores ani; coccyx and lower sacrum cut away. *b*, Sagittal section of the pelvis. Rectum and external sphincter uncut; internal sphincter being within the rectal wall. Line shows normal peritoneal limits.

rhoidal, a single direct trunk, a branch of the inferior mesenteric artery, runs in the loose tissue of the mesentery of the sigmoid, crosses the left ureter and left common iliac vessels as it descends into the pelvis, and reaches the gut at the second sacral vertebra, where it divides into two branches which descend on either side of the rectum. About five inches above the anus these divide into a half dozen branches, which soon pierce the muscular coat, running between the mucous and muscular layers of the gut, and at the lower end of the bowel anastomose with the branches of the middle and inferior hemorrhoidal arteries, forming a rich vascular plexus. The middle hemorrhoidal arteries, somewhat irregular in origin, but most commonly from the anterior trunk of the internal iliacs, aided by the inferior vesical arteries, supply the lower part of the bowel and integument of the anal region, in common with the inferior hemorrhoidals branching from the internal pudic vessels.

The inferior hemorrhoidals cross the ischiorectal fossa, but the upper vessels lie within the pelvis, above the levator ani muscle.

The plexus of veins arising from such an arterial supply is large and of unusual arrangement, forming the hemorrhoidal plexus, a venous circle about the bowels, partly in the muscular but mostly in the submucous coat. The return venous current from the rectum has this unusual course: the upper part, derived from the arterial supply of the superior hemorrhoidal artery, empties into the inferior mesenteric vein, and discharges into the portal circulation, while the lower portions of the plexus empty into the middle and inferior hemorrhoidal veins, thence through the iliac, and into the ascending cava and the systemic circulation.

The vesicoprostatic plexus communicates with the hemorrhoidal behind. These veins are prone to varicosities. The hemorrhoidal veins have but scant support in the loose cellular tissue of the rectal walls, and are exceedingly prone to varicose conditions, due, no doubt, to the hydrostatic pressure of the portal column of blood, increased by pressure of fecal contents in the rectum, and by stasis in the liver, from any of the many causes of trouble in that organ.

These venous spaces, comparatively large when under pressure, and communicating so freely and directly with the portal circulation and the systemic, are, fortunately, not very prone to septic infections in disease, accident, or in surgical work.

The **lymphatics** of the rectum are of large size, and follow very closely this vascular arrangement. There is a free communication between those around the anus and those about the pelvic part of the gut between the submucous and muscular layers. The anal portion drains into the glands of the groin; while the rectal lymphatics communicate with those of the subperitoneal layer, passing through very small glands in the margin of the gut, and thence to the sacral glands and those along the iliacus muscle.

The inguinal glands should always be examined in low rectal cancer. The lymphatics of the rectum are not nearly so numerous as those in the uterine region of the pelvis, and systemic invasion from pelvic-rectal carcinoma is not nearly so frequent or so early as in the same disease invading the uterus.

Examination of the rectum by dissection at once shows that it must be considered to present two distinct portions: First, that which begins at the third sacral body where the sigmoid ends, descending into the sacral hollow to the second or anal portion, where the narrowed bowel is grasped by the internal sphincter muscle. From that point to the skin is the second portion. This is about 2 inches long, while the dilated portion is $3\frac{1}{2}$ to 4 inches long. In its lower part this may dilate to nearly the width of the pelvis, forming a pouch-like fullness, called the ampulla. The direction of the anal portion is upward and forward on a line which would terminate at the navel. This forward direction the surgeon and the nurse should remember when introducing the finger or any instrument into the rectum; but after the first inch the rectum swings backward into the hollow of the sacrum and the finger or instrument should follow.

The **mucous lining** is highly vascular, and when the bowel is not

dilated the cellular submucous coat is so loose that the mucosa is thrown into many folds, creasing naturally both lengthwise and across the bowel. As this lining approaches the anal portion it is gathered into longitudinal columns or folds (columns of Morgagni), converging at the sphincter muscle, and forming shallow pits between, which are doubtless the cause of many minor perforations from entrapping small foreign substances.

Along the course of the rectum are three major folds of mucosa, placed like crescentic folds, one standing crosswise on the anterior face of the bowel, low, within two inches of the anus, and one on the opposite side in the sacral hollow, while another guards the region of junction with the sigmoid. These valves, first described by Houston in 1830, have some of the natural circular muscular fibers in their composition, but mainly consist of the mucous, cellular, fibrous and longitudinal muscular structures of the normal gut, extended inward. They form flaccid shelves, as it were, when the bowel is partly full—and perhaps have no further function than to help support the contents of the rectum in the interval between expulsive acts.

Within the grasp of the sphincter and at the anal margin, the mucous membrane reaches its greatest sensitiveness. Here we have the distribution of branches of the pudic nerve, along "Hilton's white line," where the nerves descend between the sphincters. This anatomic line represents the junction of mucous lining of the canal and inturned cutaneous tissue, and is distributed on a narrow circle just between the internal and external sphincter. This highly endowed area of tissue guards the outlet of the bowel, and is extremely sensitive; reflexes of pain and motility being intimately related to other portions of the body.

The **musculature of the bowel** has the same interest that pertains to that of the stomach and other parts of the alimentary canal; for it must not be forgotten that it is but one part of the same alimentary tube which begins at the lips and ends at the anus, with exaggerated development of one or another of the constituent parts of its coats at various points. The sphincter ani corresponds with the lips and the cardiac and pyloric sphincters in being an exaggeration of the circular fibers. So in the upper rectum we have fewer circular and more longitudinal fibers, with a proportionate propulsive force; making, as it were, a large elastic receptive sac capable of relaxation, to receive the effete contents of the colon, and at once contracting upon them by longitudinal shortening, with simultaneous relaxation of the sphincter, and prompt expulsion. This power is entirely independent of the abdominal compressing forces, as is shown by inflammatory or irritative disturbance of the mucosa, when so-called "tenesmus" or straining occurs, emptying the rectum of even the smallest amount of contained mucus, by intrinsic contracting power.

The **physiologic functions** of the rectal mucous membrane are both excretive and secretive, in which it is highly endowed, and to which it is as remarkably adapted as other parts of the alimentary canal. It is of much assistance to the surgeon to keep in mind the fact that directly after food is taken into the stomach the entire canal becomes active,

each part busy with its own functional secretions. The rectum promptly throws out a liberal supply of mucus, which with the extension of the wave of peristalsis from above prepares for an expulsion of effete material.

Within half an hour, if the colon has not been properly emptied, the process of absorption which has begun upon the food in the upper part of the canal begins also in the rectum, and the exuded mucus, plus the scant remnant of nutrition and preponderating toxins in the fecal contents, rapidly become absorbed. Hence the dry character of the stool, and the depressed mental and physical condition of the invalid when defecation has been delayed.

The **power of absorption** of the rectal mucous membrane is great, and is an important asset to the surgeon. It is useful for medication, for nutrition, or for absorption of sustaining fluids. It has been demonstrated that chyle can be found in the absorbents from the rectum, hence we are prepared to see a reasonable reliance placed upon it in food absorption. And it seems probable that by use it becomes trained to absorb nutrition in compensation for the interrupted use of the stomach.

Predigested milk, raw eggs, beef peptonoids, etc., are completely absorbed and may sustain the vital forces for weeks. Medication is equally effective whether given by rectum or by mouth. Morphin, chloral, and strychnin can be relied upon to act with precision, when put into a clean rectum, so as to be distributed wholly upon its membrane.

The power of absorption has been tested for gases also. Observation of the readiness of the intestines to generate and absorb gases collecting within, led Pirogoff, as early as 1847, to suggest etherization by way of the rectum. This was thoroughly tested in America by Weir, Bull, and others in 1884, and was found to be feasible by introducing vapor of ether from a bottle placed in hot water through a tube into the rectum. In three or four minutes the breath became etherous and anesthesia commenced (the colon must be empty for good effect), and complete general anesthesia was effected in five to thirty minutes. Vomiting was found to be less than when ether had been administered by the lungs. The intestines became inflated. Frequently, however, there ensued so much intestinal irritation, with numerous evacuations and, in some, bloody stools, that the method was abandoned as unsafe.

In the same proportion that the rectum can be excited to unusual action by over-irritation, it can also be thrown into absolute inaction by diverting the current of normal contents, and causing discharges of the bowel through an artificial anus in the colon. This is of immeasurable value in checking the growth of rectal cancer and ulceration. Further than that, it has been demonstrated that when a portion of the rectum and sigmoid has been closed at both ends and left *in situ*, the secretion of mucus ceases, or at least the balance between secretion and absorption is established, and the closed sac becomes as harmless as any ductless gland, no outlet being required.

The physiologic adaptation of its requirements is seen also when, after resection of a cancer low in the rectum, the gut is left opening into the

vagina, and the end of the sigmoid at the artificial anus has been sewed up and dropped back into the abdomen; there is almost an entire abeyance of mucus-secretion.

Pathologic conditions found in the rectum result from two causes: First, development of embryonic tissue into neoplasms; second, ulcerative growths from irritation or infection.

The fetal development of the rectal structure is from the external epithelial layer of the ovum. Infolded on the abdominal aspect it becomes the alimentary canal, while on the dorsal it becomes the spinal. At the junction of these, in the very early weeks of embryonic growth, there is a portion where there is practical continuity. This soon becomes obliterated by a covering in of the entire dorsal surface over both; and in an atrophic state the so-called post-anal gut lingers until reduced to a

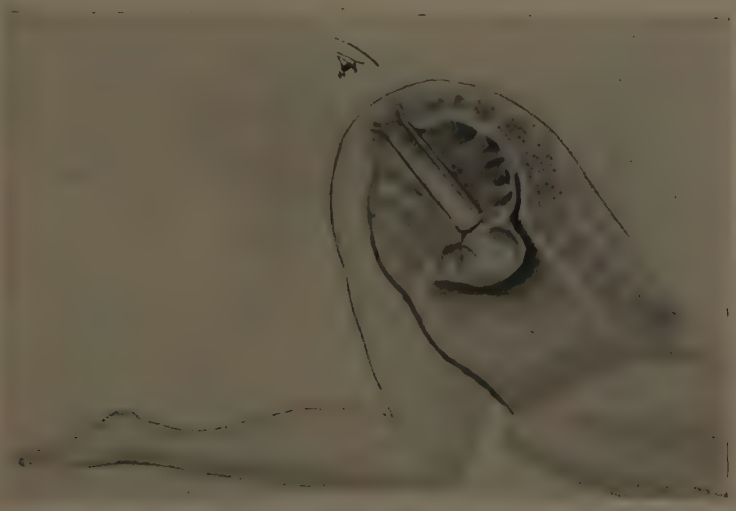


Fig. 78.—Rectal and Sigmoid Inspection by Electric Illumination with the Patient in the Knee-chest Position.

cellular remnant. At this step a dimpling of the external epiblastic layer takes place at the site of the anus; which unites with the internal tube to complete the rectum. It is in this region of embryonic fetal structures that we find development of tumors, just as in the neck and face the branchial clefts constitute a region favorable for neoplasms.

Examination of the Rectum.—No study of rectal diseases can be satisfactory unless a knowledge of the methods and aids which have been found helpful is possessed.

Examination by the eye and the educated finger will reveal to the surgeon enough to satisfy him as to many of the diseases of the anus; but unless he is careful to use a speculum for internal observation, he will frequently miss the essential causes of trouble, both in the anal and higher parts of the rectum.

At the margin of the anus, for example, he may find an inflamed tab

resembling skin. Unless he introduces a speculum, such as will soon be described, he will usually miss seeing an ulcerated fissure, of which the tab is only a sentinel at the outer edge.

A persistent dysenteric or bloody discharge may be treated ineffectually for weeks by medicine or suppositories; when by speculum exhibition a few small ulcers may be seen and quickly cured, so as to end the dysenteric symptoms.

Examination for external conditions and appearances can best be made with the patient in the lithotomy position, with the thighs well drawn up. The patient is thus better able to strain down, and the

FIG. 79.—1, 2, 3, TUBULAR RECTAL SPECULA (Kelly); 4, ELECTRIC ILLUMINATING SPECULUM WITH MAGNIFYING EYEPIECE.

perineal tissues spread out better, enabling the surgeon to probe fistulas, if present, and to press upon this and the ischiorectal fossa to discover concealed indurations.

Ocular inspection of the anal portion of the gut, or of the lower rectum, can best be conducted in this position, if the pelvis is raised well and a strong light comes from behind the surgeon. The one great objection to it for inspection is the inevitable descent of interfering liquid or soft fecal matter. Hence the Sims position, with the hips well elevated, has many advantages, besides being much less objected to by women. In this position also there is the greatest advantage to the examiner in passing

the index-finger, which can detect disease of the rectal walls at least two inches higher than in the dorsal position, as the resilient perineal tissues allow backward pressure to the coccyx. Usually the tip of the finger can explore the entire internal aspect of the sacrum to the promontory, the whole of the rectum being accessible to touch.

For thorough illumination and inspection of the interior of the entire rectum, however, there is no position as advantageous as that in which the patient is on his knees and elbows, with thighs well flexed. The abdominal viscera then fall away from the pelvis, and, as soon as the speculum opens the anus, there is a noisy drawing in of air, which spreads wide the rectal walls. Immediately the crescent valves of Houston appear, curving from side to side, the lowest one being against the bladder. These require depression by the instrument, which then passes readily on. In this position all fecal contents gravitate away from the field of inspection.

Illumination of the interior is accomplished either by the head-mirror, which is admirable, or by electric illumination, which is unequaled. Tubular specula of varied lengths (Kelly) are illustrated herewith (Fig. 79). One has a channel to pass a small electric light into. The light appears at the internal end and illuminates the cavernous rectum; this exhibition may be carried into the sigmoid. The best average tube is not more than seven inches long, which answers for all practical purposes.

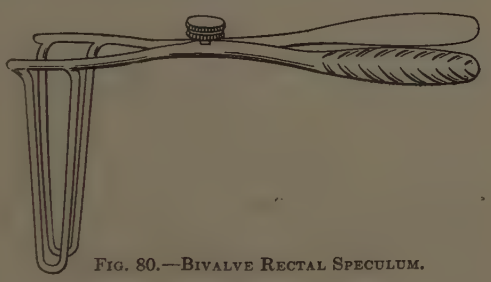


Fig. 80.—Bivalve Rectal Speculum.

Application to ulcers beyond this can be made through it, as the bowel wall is held away by atmospheric distention, two or three inches beyond its inner end. Long sticks of fine wood—eighteen inches long and less than an eighth of an inch thick—bearing a little cotton twisted on either end furnish the best means of applying treatment to ulcers visible in the field of the speculum.

A great variety of specula have been devised for inspection, and for exposing an operation field within the bowel. One of the most useful is pictured here (Fig. 80). A small bivalve which is easily introduced will give perfect exhibition of a linear fissured ulcer—a fistulous opening; but a tubular speculum, with obturator removed after introduction, allows the mucous membrane to fall into the field of vision as it is withdrawn, and exhibits inflammation, ulcers, or small tumors.

Malformations.—Abnormalities and deficiencies of the lower end of the gastro-intestinal tube were noticed and written of by the ancients. One of the first and most authoritative classifications of the different forms was that of Van Papendorf, in 1781. Bodenhamer in our own country added another chapter to the thorough understanding of the subject in 1860.

These malformations are due to the fact that the rectum and anus are developed separately, the former from ectodermal and mesodermal (internal) structures, and the latter from epidermal (external). The study of embryology has added largely to the understanding of the nature and classification of congenital rectal defects. Very early in development the lower portion of the primitive gut connects with the neurenteric canal (post-anal gut), but this junction speedily disappears, leaving the intestine closed behind it and terminating in a cloaca common to it and the urachus.

FIG. 81.

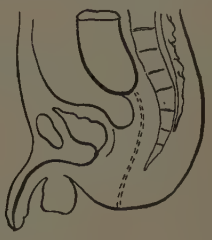


FIG. 82.

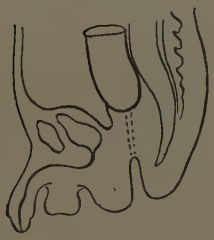


FIG. 83.

FIG. 84.

FIG. 85.

FIG. 86.

FIG. 87.

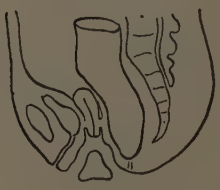


FIG. 88.

FIGS. 81 to 88.—TYPES OF IMPERFORATE ANUS.

Fig. 81, Blind rectal pouch near anal dimple; Fig. 82, same higher up; Fig. 83, blind rectal pouch high in the pelvis; deep anal outlet; Fig. 84, rectum discharging into bladder; Fig. 85, three types of rectal fistula—perineal, scrotal, penile; Fig. 86, urethral; Fig. 87, rectum discharging into vaginal fourchet; Fig. 88, blind rectal pouch—anal opening joined to vagina.

During the second month the perineal partition divides this dilatation into the urogenital segment and the rectal. At the same time a depression at the anal site (proctodeum) forms in the skin, and lined by epiderm, extends inward to meet the blind end of the ectodermal tube, into which it opens.

In arrested or irregular development of one or more of the several structures we have the basis for the various malformations, which may be classified thus:

(A) Imperforate anus.

1. Congenital narrowing of anus without complete occlusion, or without fecal fistulas elsewhere.
2. Closure of anus by thin membranous tissue.

3. Entire absence of anus, the rectum ending in a blind pouch at varying distances from the perineum.
4. Imperforate anus with fecal fistulas opening (*a*) into uterus and vagina; (*b*) into male bladder or urethra; (*c*) or on the surface of the body.

(B) Imperforate rectum, with anus normally placed.

1. Membranous obstruction of the rectum.
2. Extensive obliteration or total absence of the rectum.

(C) Rectum and anus normal, but the ureters, uterus, or vagina emptying into the rectal cavity.

(D) There may be also an absence of the large intestine, absence of a normal anus, and fecal opening at the umbilicus or elsewhere.

Some one of these defects occurs in about one in eight or ten thousand births (Figs. 81 to 88).

It is very common for this defect to be overlooked at birth, especially if the anal dimple appears normal; and the early evidences of trouble are only noticed by the absence of the usual discharge of meconium, or an unusually full appearance of the child's abdomen, with restless manner. The distention may not occur for two or three days, as there is little wind formed in the intestines, owing to the infant being always born with bacteria-free contents of the bowel, contaminated later by food or anal infection.

FIG. 89.—MALFORMATION OF ANUS.

Enterodeum (hind-gut) continued as a tapering tortuous tube (*a*) along the raphe of the scrotum, and ending by a minute opening (*b*) discharging meconium near the end of the penis; *c*, anal depression—imperforate ("International Text-book of Surgery").

Children born in this condition do not usually survive many days; restlessness, distention, and an inaptitude for food wearing out the vitality of the infant. Some children live, however, for several weeks. If not operated upon, the distention may increase to large proportions.

If the occlusion is incomplete, the symptoms may be less urgent, depending on the degree of occlusion, and rare cases have even gone on

to adult life, passing feces and urine through the bladder, urethra, vagina, or through a very contracted rectum or anus.

Prognosis naturally depends on the form of occlusion. It is good when there is simply a membranous diaphragm between the rectum and the anal dimple; or when the rectum opens freely into the vagina.

In all operative forms the mortality is high. Cripps's table of 100 cases gives 50 per cent. mortality.

16 cases colon opened in the groin	11	died
3 cases colon opened in the loin	2	"
17 punctured from below	14	"
8 coccyx resected	5	"
37 perineal dissection and incision	14	"
14 communicated with the vagina	1	"
3 miscellaneous	3	"
	50	died

These statistics are a fair presentation of the peril, though Anders reduces the mortality to 37 per cent. in all forms after operation.

In brief, the condition offers to the surgeon little opportunity for hope of accomplishing brilliant or enduring results, even after the most ingenious and best technical work.

FIG. 90.—DILATED COLON FROM SECONDARY STENOSIS AFTER EARLY OPERATION FOR IMPERFORATE ANUS (Bryant).

Treatment.—Operative work, then, has the following procedures to offer:

A temporary life-saving *artificial anus* may be made in cases where the anal dimple is indicated (or even where the perineum is unmarked), if the rectal pouch is full of meconium and can be felt to bulge in the perineum on straining. An admirable illustration of the serviceableness of this, and of the difficulty of maintaining a permanently large anus, and the risk of final obstruction from stenosis is shown in a case illustrated by Bryant (Fig. 90).

For even this, the least difficult of the operative procedures, the surgeon must have a good light, ample assistance to hold the child's perineum well up to view, and good retraction of the wound. Ether anesthesia is essential to good work. A median perineal incision well back to the coccyx, followed by blunt dissection by finger or blunt scissor ends, will soon reveal the round end of the dark meconium-filled gut, if it is low enough for operative relief. If this is not found two inches inside the skin in the sacral hollow, it is unwise to proceed further, as the peril to the child from shock and the unsatisfactory nature of the resulting anus will not justify the work. Most of the cases of imperforate anus will be found to terminate in a low rectal pouch, but in the rest a fibrous cord will be the only tissue corresponding to the entire rectum; and occasionally the end of the sigmoid will be found floating free in the

abdomen among the other intestines, held only by a fibrous mesentery. In these cases further search would be hopeless, and the child should be promptly given an artificial anus in the left inguinal region. This will save life and give the child a chance to prove its viability.

Incidentally, the surgeon may well keep in view, and tell the parents, that most children with congenital defects have a naturally deficient vitality during their infancy. Hence any attempt to perfect the restoration of the parts will be a menace to the infant until some years have gone by. For this reason it is generally wise to look upon all cases of rectal defects as bad risks in surgery, and simply offer a well-made artificial anus in the left inguinal region as, *ab initio*, the surgical procedure of choice.

In later years, if the case has been one of *fecal fistula* into the perineum or genito-urinary tract, a long absence of fecal discharge except through the inguinal anus will allow the fistula to close by nature's great law of stenosis of such defects.

In view of the survival with such congenital defects, what surgical procedure can be offered? Each case must be a law unto itself, and excite the surgeon's ingenuity. But there is no one defect which may not, with more or less peril, be overcome.

The vesical fistula would seem to be most in need of repair, inasmuch as the feces contaminate the urine, and gas and dissolved feces may be passed for years without a fatal end. Nature is sometimes tolerant of such defects, and infection does not always ascend the ureters.

Without specifying individual types of *rectovesical defects*, the surgeon will proceed along the lines applicable to resection of the rectum by the coccygeal and sacral route. The lateral prone posture—a long median posterior incision; exposure of the viscera by cutting through the levator ani muscles; isolation of the rectum; dissection from the bladder (with a catheter guide in the bladder); freshening and suture of the vesical wound; stitching the rectum down to the anus, or closing it entirely, or connecting it with a sacral anus, and leaving a wound partly open to heal by granulation—will most always bring about a cure. It is almost a *sine qua non* in such a case that the bladder must immediately be drained by the perineal route, and must be irrigated daily with boric acid solution for ten or twelve days.

Urotropin, grs. v, t. i. d., will further purify the contaminated bladder urine, and insure success.

In female children the rectal defect opens most commonly at the outlet of the vagina at the fourchet. This admits of good repair, but the ultimate result, as far as continence of feces goes, is rarely good.

The perineum should be split through from the fistula to the coccyx, the fistula dissected up to the sacral portion of the gut, which is then loosened from the vagina and pelvis, and brought down to the correct anal position, where it is opened and sutured. Afterward the perineum is repaired also by suture.

Most all such artificial ani give a trumpet-shaped anus without sphinc-

teric action, the muscular innervation is defective, and admits of easy prolapse of mucosa afterward.

Wounds of the Rectum and Anus.—These may be either emergencies or produced by surgical mishaps. The weight of the body in falling upon sticks, picket fences, iron rods, the handle of a hammer, a portion of a broken crockery chamber-pot, or the violent thrust of an animal's horn, a cane, or an umbrella, will occasionally cause penetration of the anus, or of the ischiorectal tissues and the rectum; while the violent use of a stiff rectal syringe or a bougie in dilating a stricture may easily penetrate the tender wall of the upper rectum. Many such cases are within the experience of most surgeons, and one soon realizes the liability to and the gravity of infection in these cases.

The wound does not usually penetrate the peritoneal cavity or the bladder, but it may do either or both, and in the case of a fall upon sharp objects it is the first duty of the surgeon to make prompt examination under anesthesia, with great thoroughness, if there is shock or evidence of hemorrhage. It is just as necessary to be prompt and thorough in treating with a case as it is to insist on the prompt treatment of a compound fracture under ether, no matter how small the skin defect. The concealed and easily infected nature of the part injured demands early cleansing and drainage.

Stretching of the sphincter, with drainage of the rectum by a rubber tube wrapped with iodoform gauze, after inspection of the mucous membrane, and cleansing or packing any small internal lacerated wound, will prevent the otherwise inevitable perirectal infiltration due to confined gases and feces.

If there is any reason to suspect peritoneal infection,—indicated by abdominal tenderness, rising temperature, vomiting, restlessness, or shock, or by discovering that a blunt instrument passes through a rent in the anterior rectal wall,—it is the imperative duty of the surgeon to open the abdomen suprapubically and explore the pelvic pouch by sponges for evidence of soiling; and if this is found, to wash the nearby coils of intestine with normal salt solution; cleanse the pelvis likewise and drain it by tube and gauze passed out of the pelvis, through the rectum and out of the anus.

Stretching a high rectal stricture by a hard bougie carries a considerable risk of piercing the diseased wall, and may be followed by abscess and pyemia, if it does not enter the peritoneum and produce peritonitis.

Laceration of the rectal wall by violent pressure of childbirth carries little risk of infection, owing to the rectovaginal septum being torn through and the best drainage established. Repair is admirably effected by perineorrhaphy.

The author was recently called to the country to operate on a child of three years for acute peritonitis, supposed to be from appendicitis. On narrating the history the mother said the child had complained of stomach pain, for which she gave an injection into the bowel, with the child laid across her lap, using a hard-rubber rectal tube of adult size. The child struggled violently, but the mother attributed its resistance to dislike of the enema.

Peritoneal distention and fever followed, and when operation was performed the enema was found in the peritoneum.

Foreign bodies in the rectum contribute a weird chapter in the surgery of this part. The surgeon is called upon to remove either objects swallowed, which have passed through the entire alimentary canal without injuring it, and then stuck above the anal sphincter, or objects which have been introduced into the rectum from various motives. Perhaps the most common motives have been to relieve pain of hemorrhoids by internal pressure, to hold back piles or prolapses of the rectum and stop hemorrhage, to satisfy a prurient sense of unnatural pleasure, or to arrest a continuous itching of the anus.

In one remarkable case of Thorndyke's, of Boston, a sailor had ingeniously practised relieving his occasional retention of urine by crowding a blunt bottle up the rectum, and thus assisting his bladder to evacuate itself. On one occasion he substituted a long, smooth stone, which slipped from his grasp and nearly lost him his life, as it perforated the peritoneal cavity, and was removed from among the intestines by laparotomy.

The narrative of the variety of objects so discovered sounds like a Munchausen tale. Objects smooth and rough, sticks, bottles, cane ends, crockery, cups, metal objects, and stones, are but a few of the objects found. Their use is often concealed by the patient.

Treatment.—The ingenuity of the surgeon will be taxed to remove these without further injury—whether it be an open safety-pin, a large smooth object, or a stick or bottle. The sphincter closes over it and it will be usually necessary to anesthetize the patient and stretch the muscle. Extraction of most foreign bodies will be facilitated by a bent loop of heavy wire (telegraph wire), bent hook fashion at its end, aided by good anal retractors and by lithotomy forceps which have a smooth wide bowl, applied like obstetric forceps, preventing anal injury during extraction.

Few foreign bodies result in grave danger, though inflammation and abscess may extend into the ischiorectal fossa.

Inflammation of the Rectum and Perirectal Spaces.—Catarrhal, ulcerative, or infected inflammation of the mucosa of the rectum (proctitis) is a not uncommon affection in mild degree, but it may become chronic or may extend to the perirectal tissue and menace life.

In children its origin is usually mechanical, from causes such as pinworms, or the persistent use of glycerin or irritating suppositories or severe enemata; or it may be the final stage of a dysenteric enteritis.

In adults its simplest form may be seen in irritation of the rectum after prolonged use of nutrient enemata, and in severer form from dysenteric infection, or gonorrheal, syphilitic, or bacterial inflammation.

The presence of hardened scybala long retained and irritating the rectal wall, even to ulceration; the presence of small rectal polypi; adenomata, or ulcerated hemorrhoids, producing by their presence a tenesmus, congestion and catarrhal inflammation; or infection through cancerous growths with loss of mucous membrane;—and finally the

cellulitis following infected wounds, traumatic or surgical (including those produced from within by spicules of bone, oyster-shell, pins, husks of cereals, or hard bits of fecal matter pushed through the mucous wall after being entrapped in follicles or normal folds), are some of the causes of inflammation requiring surgical care.

The **symptoms** of the catarrhal or ulcerative type are those of dysentery: constant tenesmus with squirts of thin mucus, a little thin feculent matter, and streaks of blood; general distress of mind and body, with neuralgic pain in the pelvis, bladder, and down the thighs, often producing considerable loss of flesh, inaptitude for food, and disablement from work.

Speculum examination shows abundance of tough mucus clinging to red, inflamed mucous membrane, and in places loss of epithelium, or small patchy ulcers, which bleed easily on swabbing. There may be a streptococcus infection with the formation of false membrane, which may be thrown off in sheets. Even diphtheritic membrane has been seen lining the canal.

Treatment.—The treatment of these types should be cleansing, antiseptic, and soothing. Doubtless all are more or less infected by bacteria in a state of activity and unwonted virulence. Hence the first local application should be directed to their control. Nitrate of silver solution (10 grs. to the ounce), swabbed on the surface, has stood the test of years better than any of the severer bactericides.

Following one or more such applications, irrigation of the whole rectum twice daily by warm boracic acid in a half-strength saturated solution will do more to quickly and permanently quiet the inflammation than any other mild antiseptic. In addition to this, a four-ounce demulcent flaxseed enema (℥ij whole flaxseed boiled in a quart of water), to which is added ten drops of laudanum, will put the rectum at rest. The retention of this will depend on making brief gentle pressure on the fundament, until the equilibrium of the sphincter muscles has been established.

In severe ulcerative proctitis one or two applications of nitric acid on a cotton swab to the ulcerated surface will usually cure when nothing else will.

Once the infection has penetrated to the perirectal cellular planes, we have to face anatomic factors which must be understood in order to combat the tendency to pelvic and systemic invasion.

Granted that infection has escaped through the broken mucosa, it enters cellular planes which are so loose that this layer moves more or less freely on the muscular. The escape of septic material, therefore, is along a plane in the anal part outward into the rectal fat; while above the internal sphincter it spreads into the pelvic rectal space, and thence breaks through the levator ani muscle and invades the ischiorectal fossa.

Ischiorectal abscess announces itself by weight and aching in the pelvis, and tenderness in pressing about the anus, with coincident malaise for two days. Then a chill, sharp fever, 103° to 104° F., dry tongue, headache, backache, and painful defecation. Examination shows a characteristic bulging at one side of the anus extending to the ischium. It throbs and is most tender.

It is a waste of time to apply ice or poultices. If the confined septic pus is not evacuated, the tendency is to spread into all the fat and cellular tissue, which becomes necrotic, and it is not uncommon to observe a large purple swelling of the nates, which, when evacuated at last, gives exit to foul gas, masses of gangrenous tissue, and stinking pus, which continues to flow for hours.

The patient has already become pyemic and may readily die from sepsis, though, usually, operation quickly turns the tide in his favor.

Incisions have to be extremely liberal, as in all cases of septic cellulitis. A four or six inch cut parallel with the median line will suffice, and if necessary one on the opposite side when it has crossed the raphe, as it may. Thorough irrigation of the cavity, and light iodoform gauze packing with one or two drainage-tubes, lead-pencil size, put deep into the fossa, will give prompt relief.

I would here emphasize the grave error too often committed, of using hydrogen peroxid in these loose tissue infections as a purifying agent. It is a dynamic force, pushing the infection into hitherto uninvaded spaces by the gas liberated in the deeper parts under confinement, and should never be used except on open surfaces.

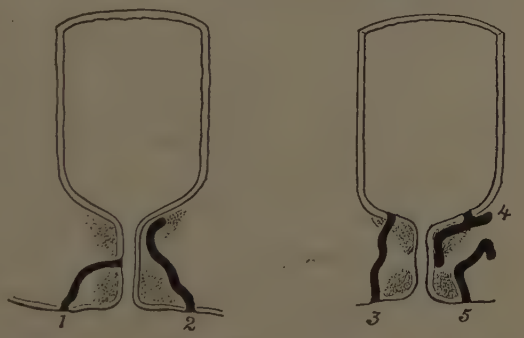


FIG. 91.—FISTULA IN ANO.

1 and 2, Usual fistula in ano; 3, complete fistula, both sphincters; 4, incomplete internal fistula; 5, incomplete external fistula.

Fistula in Ano.—Most abscesses about the rectum and anus, after evacuation, heal, up to a certain point, but, unlike those in any other part of the body, leave an unhealed channel leading from the point of evacuation to the point of origin. This fistula is most obstinate and constantly demands surgical consideration. (See Fig. 91.)

It may take one of several forms, according to its outlet. The outlet may be on the skin within one or two inches of the anus, according to the distance pus has burrowed; and the internal opening may be just within the anal margin. Or, with a similarly placed outlet, it may open into the rectum above the internal sphincter. It may open between the sphincters and burrow upward or downward with no other opening (blind internal fistula); or it may open outside and burrow up and down from an internal orifice. Thus we may find *complete* fistulas where there is an opening within and without, and *incomplete*, where there is but one opening, either within or without.

Again, we may have the *horseshoe fistula* with several openings on the skin, connecting by tortuous subcutaneous channels, all leading to one opening internal to the anus.

A *fistula* is often seen communicating between the vagina or vulva and the rectum, and at times opening from the rectum into the bladder.

The vast majority of fistulas open internally between the two sphincters, and undoubtedly originate in the small ulcer commonly found between the sphincters. In such cases an exploring probe passes from the skin opening into the anal portion of the rectum.

The obstinacy of these fistulas to undergo spontaneous cure depends on the incessant mobility of the parts, and on two factors which are more constant, namely, the escape of material from the bowel into them, and the presence of a funnel-shaped upper opening where the mucosa cicatrizes into the fistula, thus defeating the normal law of closure of stenosis after granulation.

Fistula in ano often persists for many years with little annoyance other than a slight soiling of the linen. Occasionally, however, the external opening closes and a repetition of the original ischiorectal abscess takes place.

In consumptives the type of fistula differs little from others except in sluggishness and gray tuberculous-appearing granulations. Less than a generation ago it was considered beneficial for a consumptive to have an uncured fistula; this was a relic of the fetish of an established seton or running sore in scrofulous cases. It is now universally regarded as better for the tuberculous fistula to be cured.

The **symptoms** of internal fistula are, persistent itching and a gnawing or crawling feeling within the anus, without pain. Examination by speculum in a good light will sometimes show a little pus appearing on the mucous membrane, when pressure is made outside. But more often anesthesia, rectal dilation and inspection are needed definitely to show the pocket, which will be found to be a normal crypt with a submucous channel which must be widely cut.

Operation.—In the vast majority of fistulas the surgeon passes a probe director from the skin opening into the rectum between the two sphincters, and with a knife cuts all the skin and anal margin raised on the director. This means division of the external sphincter, which does not materially weaken the muscular control of the bowel. The cut tissues should be packed with a little strip of iodoform gauze for a week, to prevent bridging over and reproduction of the fistula. It is often sufficient if the finger is merely passed along the cut every day or two to prevent premature surface healing.

It is a much more serious matter, however, to cut both sphincters, which often results in inconvenience which makes a patient suffer mortification and discomfort for life, and may require a difficult plastic operation to repair. Hence the surgeon resorts to every possible expedient before cutting both sphincters.

He may sometimes cure these deep fistulas by thoroughly stretching the muscles under anesthesia, then curetting the fistula most thoroughly, especially at its upper part, scraping out the ingrown mucous funnel—syringing out the canal—until it may be considered clean and fresh. Then by inserting into the rectum a rubber tube wound with iodoform

gauze, so as to make a plug an inch in diameter which will compress the walls of the sinus, he may cause adhesive closure which will be permanent. Much depends on thoroughness, and on preliminary catharsis for three days, with complete constipation and light diet for a week to ten days after operation. An opiate may occasionally be needed, but gas escapes through the tube and patients suffer no discomfort.

In relaxed sphincters or those which have been destroyed by deep cutting, two expedients are at command—the submucous injection of wax, after Gersuny's method, or a plastic repair, as in perineorrhaphy.

The wax injection must be made with every clean precaution and will produce a dense substitute wall for the space occupied by the muscle, giving a firm resisting dam, and thereby assisting the remaining portion of muscle, which is still active but inadequate.

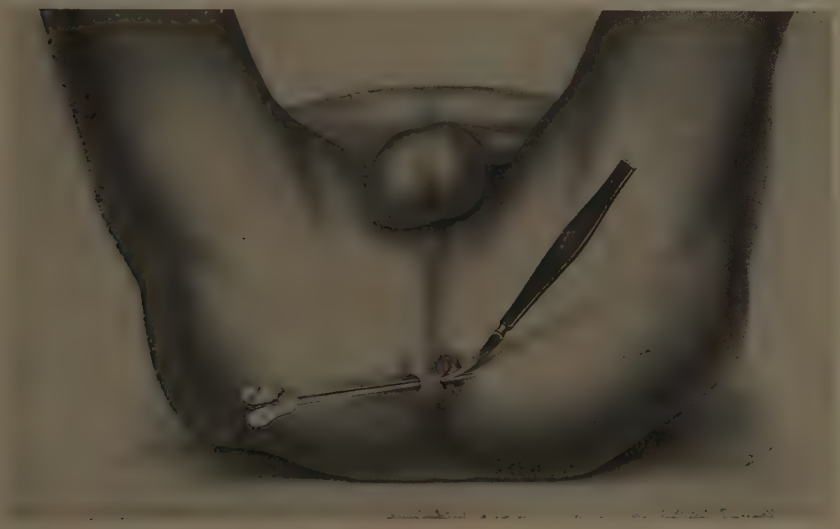


FIG. 92.—OPERATION FOR FISTULA IN ANO (Fowler).

Gersuny's Method.—The wax and vaselin being compounded to the right consistency is kept fluid in a Pravaz syringe immersed in hot water. The needle for this is used on another syringe to inject a half dram of weak cocain or novocain solution into the cellular plane underlying the anal mucous membrane and to withdraw most of this to demonstrate that the needle is not inserted into a large venous dilatation. If the fluid returns without much blood, the wax-filled syringe is now screwed on and a dram or so is forced into the space and modeled flat by digital pressure.

The *plastic operation* consists in marking an outside marginal cut on the cutaneous border, and dissecting up an unbroken tube of mucous membrane covering the outlet. This lays bare the ends of the sphincter, and a series of retention sutures to last ten days will bring them in apposition as the V-shaped cut is closed. Two silkworm-gut stitches, as in

perineorrhaphy, will hold sufficiently. A small pencil-sized rubber tube wrapped about with a single layer of iodoform gauze may be inserted in the rectum as a safety-valve for escape of gas, and to permit introducing an enema after ten days.

Large rectovaginal or rectovesical fistulas have frequently been cured by a plastic operation as follows:

In the *rectovaginal* fistula the patient is placed in the lithotomy position, the sphincter stretched, and a circular incision made at the mucocutaneous junction. The mucous membrane is then dissected up by blunt scissors, showing the sphincter muscle, and is to be separated well up beyond the opening into the vagina. The edges of the latter are then freshened and sutured on the vaginal mucous surface. The dissected tube of rectal mucous membrane is then drawn down and stitched to the skin by continuous catgut stitch. The rectal gauze-wound tube is inserted to make pressure and induce adhesion of the new tissue layer, and to protect the outer line of sutured skin. On the fifth or perhaps the fourth day the union is complete.

In the *rectovesical* fistula a perineal incision is made in front of the prostate for irrigation and catheter drainage. Then, the sphincter being stretched, the walls of the opening can be cut freshly and sutured on the rectal side firmly. It is possible to make even a separate catgut suture of the bladder wall, and a separate one of the rectal wall. Success will be insured if tension is taken off both by catheter drainage, and if boracic acid irrigation of the bladder be maintained for a week. The rectum must be put at rest by the gauze-wound rectal tube and by opiates.

Fissure in Ano.—A small crack in the folds of the anal margin, partly or wholly in the grasp of the sphincter, may be made by scratching of harsh fecal matter, or by undue stretching during the passage of unusually large constipated movements. For some unknown reason such scratches will occasionally remain unhealed for a few days, and then, owing to indurated edges, the depth perhaps touching the sphincter muscle fibers, and entrapping a terminal nerve-fiber, on its granulating surface, there ensues a series of mishaps which prevent its natural healing. Most of all, the sphincter reflex keeps the outlet guarded so as to induce constipation from sheer indisposition of the patient to bear pain. This gives double aggravation from scybalous movement. Then the nerve-end becomes inflamed and pain extends to the spinal system, impairing the patient's health. Induration of the base of the crack produces a hard ulcer which when stretched cracks and bleeds more easily. A chronic infected tender fissure at last is developed which endures for months or years, and frequently wears out the nerves and constitution of even strong patients. A neurasthenic, anemic, emaciated wreck of humanity may be at last the outcome of a small fissure. Such is the picture of the worst results of spinal reflexes from an irritated fissure.

On the other hand, a persistent fissure, even if of larger size, may remain unhealed for months, merely because of the incessant play of the fibers of sphincter muscle underlying it, and give little pain, though occasionally bleeding.

Women of neurasthenic tendency and false sense of modesty will conceal the anal trouble or refuse examination until the observant practitioner disarms them by wisely suggesting that "nothing is indelicate that is necessary." Digital exploration is often the only thing necessary in examination, for the extremely tight sphincter ani and the shrinking patient immediately tell the story.

The cure of fissure is accomplished in one of three ways. The best and simplest way is by dilatation of the sphincter under anesthesia. I have not found nitrous oxid gas generally useful, as the patient stiffens the thighs and abdominal muscles immediately on experiencing a reflex from the ulcer; thus defeating the best intended effort to stretch enough to completely cure.

Ether gives perfect relaxation. With the patient in the lithotomy position the operator introduces one finger, then two, then both thumbs, and by kneading motion causes general stretching of sphincter fibers, until the thumb surface presses the tuber ischium on each side. An opium suppository (½ gr. aqueus extr.) is left in the rectum and in a few moments the patient is out of ether.

If the patient refuses anesthesia, then the surgeon settles down to patiently conquer the pain by 2 per cent. cocain, eucain, or novocain solution applied to the outer part of the fissure, then deeper and deeper until it is benumbed. Then a solution of nitrate of silver (20 grs. to 1 ounce) is applied to the ulcer. Some even draw a solid stick of silver nitrate along the fissure. This is repeated two or three times weekly with persuasive efforts to dilate by smooth steel sounds, which, in time, will accomplish all that is necessary.

If the fissure can be numbed enough by cocain, a drop of the same can be inserted into the base of the sore by a hypodermic needle, and a knife can be drawn along the base, cutting into the muscle enough to break the continuity of the underlying muscle-fibers. By one of these methods the most intractable and painful fissure can be cured.

Ulcers of the anus and rectum are either simple, tuberculous, syphilitic, or malignant.

Any of these may be found at the margin, or in the grasp of the anus, or higher up on the rectal wall. The simple variety may begin at the anal margin as a fissure or within the rectum; it may be dysenteric or amebic.

The term *dysenteric* may be well used to include varieties of infected ulceration (such as are not included in tuberculous or syphilitic, although the latter are specific infections). Many of these are associated with inflammation of the colon mucosa, and are of short duration, representing abrasion and loss of superficial epithelium rather than deep ulcers; but accompanied by exfoliation of sheets of lymph with epithelial cells clinging, and with discharge of blood from underlying bare surface. This type heals without apparent injury to the tissue.

Yet any of the infected type may, at different stages, be represented by shallow abrasions; small, follicular, worm-eaten ulcers, undermining the mucosa; or flat, wide, punched-out erosions. If by chance they

may be caused by scratching of rough food particles, by mechanical irritation of chemicals (injection of mercury bichlorid, carbolic acid), by erosion of varicose hemorrhoid surfaces, or by pressure of hard scybala packed into the ampulla, or even a traumatism from injury or surgical effort, they are quickly infected by the intestinal bacteria, and at times persist, though prone to heal naturally.

The *amebic* type are prone to persist. They are shallow ulcerated surfaces, characteristic of cases of tropical dysentery transplanted to cool climates, and are one of the causes of hepatic abscess.

The amebas are directly transported by the hemorrhoidal veins to the hepatic system. The surface of these ulcers, as well as the abscess of the liver, yield living amebas, readily found under the microscope. Careful inspection of the rectum by a well illuminated speculum will give the surgeon a chance to apply nitric acid on a cotton swab to each ulcer, which with rectal irrigation by warm boracic acid solution will quickly cure the case.

Tuberculous ulcers are produced in tuberculous patients by auto-inoculation by sputum, the tuberculous bacilli being pressed into follicles and abrasions. These with associated pyogenic bacteria soon produce a penetration into the submucous cellular plane and beget small, sluggish abscesses which spread up and down from their origin, and when opened give tuberculous fistulas. This type of ulcer is occasionally multiple, and often gives no pain, but yields a purulent surface discharge and occasional streaks of blood. It may, however, be very extensive after long development in tissues of slight resistance, when they show a more foul and sloughy character.

Patients suffering from tuberculous ulcers are not generally in good condition for extensive surgical treatment, and while much more can be done under anesthesia, they must be considered as bad surgical risks. Hence patience, local cocain applications, and rectal irrigation are among the most helpful agents of relief.

The tuberculous ulcers may extend from one end of the colon to the other when only the rectal ones may be in evidence. Hence the persistence of a chronic colitis with emaciation, out of proportion to the visible ulcers, will warn the operator not to expect too much from treating only the rectal ulcers.

The sluggish fecal current from the caput coli to the anus gives opportunity for invasion of the bacilli in any part of this tract, but naturally with greater frequency in the lower end, where traumatism of hard fecal matter is more common.

The *treatment* of chronic tuberculous ulcers of the rectum, therefore, may well be combined with that of those higher in the colon—by rectal irrigation.

In this form we have most important and efficient help in the use of two methods. First, the irrigating tube, which need not be long, which is placed just within the anus and by a gentle flow of warm salt solution allows flushing out the entire descending and often the transverse and perhaps the ascending colon, after which a boracic acid solution is allowed

to flow in and out, which medicates the canal and has great healing properties.

We have in a simple surgical procedure an opportunity more perfectly to flush the colon from end to end. This consists in establishing a small artificial fistula at the caput coli,—easily done under cocain anesthesia,—and persistently flushing the colon from there to the anus daily for weeks.

This method was inaugurated by Gibson for treatment of tropical dysentery, and has proved a great boon. Weir's modification by irrigating through the appendix, which is left in the wound permanently, has much advantage.

Syphilitic ulcers are uncommon about the anal margin, in either the primary or the secondary form. Under the term syphilitic one may include the venereal chancroid, for simple description's sake. This is not as rare as the Hunterian chancre, and in women is said to be present as frequently as once in nine cases, while in men it is hardly ever seen. The anal chancroid is probably an auto-inoculation from the primary nearby sore. Its presence inside the rectum is extremely rare, but has been known to produce a phagedenic type of ulcer, with sloughing of the rectal wall.

Medical literature does not yield any case of true primary venereal sore inside the rectum. Nevertheless there are secondary patches at the anus, and tertiary ulcers within, which are true syphilitic disease. Mucous patches are common, and present a wet, swollen, foul, gray, secreting surface, which by reason of the confined space and contact with the opposite side of the anal skin usually engender hypertrophic changes of condylomatous type, often making large, damp, wart-like growths. These latter are hardly to be distinguished from verruca condylomata of non-malignant type, unless the mucous patch can be easily identified, or others in the mouth or vulva demonstrated, or unless early syphilis can be proved.

The proneness of surgeons to pronounce certain ulcers of the interior of the rectum, not otherwise accounted for, to be of probable syphilitic origin is not borne out by the facts. Until a specific lesion of the disease or microscopic characters (spirochæta) can be demonstrated, more conservative statements must prevail. Incidentally the administration of anti-syphilitic treatment rarely adds to the efficiency of local treatment in curing them. These points are rightly defended by Kelsey from experience and conscientious study of the subject.

Malignant ulceration of the rectum can resemble other types in its early development. No doubt the development of adenoid types of growth when early ulcerated, as often happens, from devitalization and disintegration of the central parts, produces an ulcer which may closely resemble the tuberculous. In either case (we will suppose an ulcer of the size of one's thumb-nail) there will be a destruction of the central growth and either a raw bleeding surface (if it be malignant), with heaped-up red granular base, hard lumpy edges, and ragged mucous membrane, with some sanious pus secreted by its surface, or (if it be tuberculous) a gray sluggish base with flatter and softer base and edges, not bleeding or

secreting pus. Possibly the caseation of deposits of tubercle which produced the broken-down ulcer may have spread so as to undermine the mucous edges, and some suppurating channels may have formed.

Malignant ulcers involve submucous areas, usually, and a hard, condensed, movable plaque of growth will be felt by the finger if it be localized on one side, or, if the ulcer surround the lumen, as most do, there will be felt a ragged cylindric mass, always narrower than the lumen of the bowel, and edged above and below by a fringe of loose tabs of membrane turned away from the ulcerated surface—very much as the serous lining of the artery turns away from the furrow cut into the inner coats by a tight ligature on the outer side.

A hard-edged malignant ulcer will often encroach on or be in the grasp of the sphincter, and be associated with other non-ulcerating adenomata of the same character at points above within reach of the finger. At the anal margin there will be a protrusion of part of the ulcer, in time, with swollen tabs of mucous membrane, while above the sphincter the growth will have the tendency to expulsion by oft repeated rectal impulses.

Both these types, however, will have the hard base and raised, red, bleeding and secreting edges, and usually much less pain, to distinguish them from the more frequent anal ulcer previously described.

The *treatment* of malignant ulcers must be on radical lines, which will be described under cancer of the rectum.

Strictures of the Rectum.—Any chronic ulceration or inflammation of the mucous membrane of the rectum may in time result in a narrowing and closure of the lumen of the bowel. It has long been a disputed point, still far from being settled, as to the most prevalent causes; syphilis in its third stage and chancroid having been most commonly ascribed as a cause of the deep, hard, fibrous masses extending a finger-length up the bowel. Yet it is undoubtedly true that in the great majority of such strictures no suspicion of that disease can be had. Hence Kelsey and some others discard that bugbear and refuge of ignorance, and prefer to consider a chronic proctitis of simple type as more correctly an ascribable cause, when no other is clear.

A study of some cases will reveal preceding accidental ulceration, or an operation for hemorrhoids unskilfully done, or a history of desquamative dysentery with probably phagedenic ulceration. But after excluding these there remains a class of dense-walled, tight strictures, through which the finger passes with difficulty, smooth lined in some parts, ulcerated in others, occasionally bleeding a little, conical shaped and narrower as the finger goes inward. The anus is often relaxed and trumpet-shaped, owing to the inflammatory infiltration of the sphincters, which have long been out of use, owing to the narrowing above.

The remains of the rectum seem to be a narrow tube of dense fibrous structure, movable often in the sacral hollow, and resembling similar stenoses in other parts of the alimentary canal. It closely resembles pyloric stenosis in the neighborhood of gastric ulcers, in all its qualities, and both have an associated infiltration, inflammatory and cellular in type.

We see, similarly, in the mucous membrane at the proximal end, or along the lumen of the appendix, typical stenoses, with associated hypertrophied walls and loss of columnar epithelium, due to purely inflammatory and usually purulent ulcerative type of lesion, taking years to develop into a stricture sufficient to produce obstructive stenosis and involve the patient's health. These are much more frequent than strictures of the rectum and have never been challenged as being syphilitic in origin. The ground taken by Kelsey, therefore, is to be considered as the most logical and humane. Opposed to this has been the advocacy of Matthews, Allingham, Cooper, and Edwards, that gummatous inflammation constitutes the majority of precedent conditions of stricture, for which view there seems little definite evidence.

By far the most common cause of strictures, however, is malignant growth, annular cylindric carcinoma with symptoms always slowly cumulative. The patient complains of alternating diarrhea and constipation, with mucus and blood occasionally. As later symptoms, small liquid stools, never large moulded ones, are the most universally acknowledged evidence, often brought out by questions of the surgeon, because the patient has become so used to taking medicine every night that it has been overlooked that normal stools are unseen. If the stricture is low down there will be tenesmus; if not, the patient may be unaware of desire to strain, or frequent stools, or even sense of weight and aching in the pelvis.

Examination by the physician will best detect a stricture, of whatever type, by placing the patient on the side, when the index-finger will reach nearly to the sacral promontory, and by conjoined pressure of a hand over the bladder the upper rectum can be crowded down upon the finger.

If evidence of stricture is strong, but nothing can be felt, the illuminated cylindric proctoscope, used in the knee-chest posture, will detect an annular constriction which may be far beyond the finger's reach. Many prefer to explore by a conical rectal bougie, but if the practitioner has limited experience he will find difficulty in passing this in many cases past the fold of the rectosigmoid juncture, and will suspect a narrowing when it does not exist. The hollow soft-rubber bougie should be used, with a syringeful of oil thrown into the upper rectum through it, to straighten out and lubricate the folds.

Treatment.—Operation on the rectal stricture consists in conservative use of bougies; in radical use of the knife; in resection of the stricture if dense; or, of anastomosis of the sigmoid into a point of rectum below the stricture when the latter is high.

Bougies are sufficient if their use can be maintained at intervals for years. If omitted, recontraction is inevitable. On the other hand, some cases are aggravated by dilatation, and bleeding and increased proctitis result. Such cases must be contented with slight dilatation at long intervals, or submit to operation.

Several times I have had patients with long-standing strictures, not more than a finger-length from the anus, use at regular intervals a bougie which I consider as safer and perfectly efficient, consisting of

an ordinary wax candle, smoothed and shaped correctly at the end by heating. This is inexpensive, clean, and easily managed by the patient, who will be more easily persuaded to use it, as he considers it less of a surgical instrument.

If the stricture be low in the pelvis, posterior proctotomy (Verneuil) will give relief, a blunt-ended, heavy, straight bistoury being carried through the stricture and forced backward as it is withdrawn, so as to completely divide everything down to the bone, including the sphincters. Temporary incontinence results, but with return of stenosis and healing, a far more advantageous condition results. There is no bleeding to be dreaded which packing with iodoform gauze on a gauze-wound tube will not control. Malignant strictures will be resected as described later.

A high stricture which cannot be dilated safely (though many of them can be) may be circumvented by turning the sigmoid rectum down into

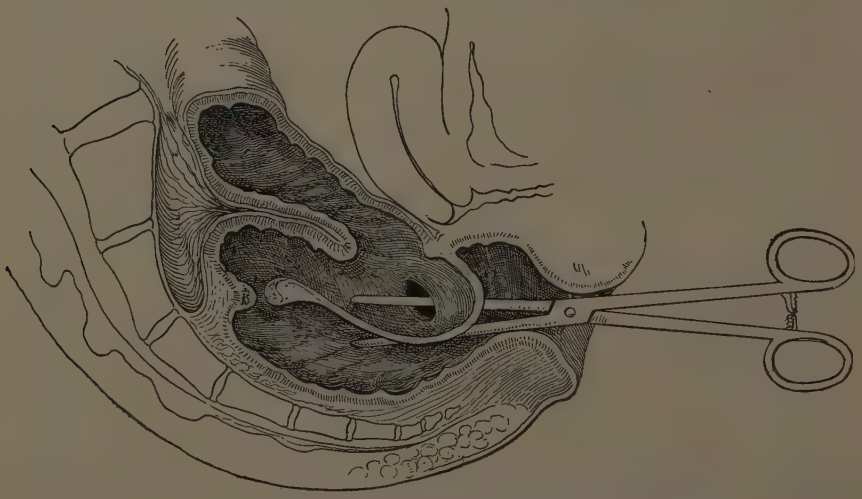


FIG. 93.—ENTEROTOME ENLARGING RECTOSIGMOID ANASTOMOSIS CIRCUMVENTING HIGH RECTAL STRICTURE. BACON'S OPERATION.

the cul-de-sac of the pelvis, having first opened the abdomen in Trendelenburg's posture, and displaced other intestines from the pelvis (Fig. 93). Then by Murphy's button, anastomosis creates a small opening at its lowest point. If there is sufficient space between the stricture and the anastomosed point to permit of a later enlargement, the two portions of gut may be stitched together above the anastomosis, and when the button has come away a clamp may be inserted per anum into the opening, grasping the adjacent layers of bowel wall, and crushing them so as to make the requisite slit opening instead of merely the aperture of the button.

Prolapse of the Rectum and Anus.—There is a popular expression of sufferers from piles that "the bowels come down." This expression is suggestive to the patient of what actually happens in true *prolapse of the rectum.* But in hemorrhoidal prolapse there is only a slipping of the mucous membrane on the muscular coat of the bowel.

The term *prolapsus ani* may include not only the slipping of the mucous lining of the lower rectum when hemorrhoidal tumors are forced out and drag the inner coat with them, but a considerable number of cases where the healthy anal mucous lining is extruded in a ring, as is normal to some animals at defecation, notably the horse, and which returns immediately after. Here the loose connective tissue holding the mucous to the fibromuscular coat is such an open network that they are feebly held together.

The term *prolapsus recti* includes much more and presents an entirely different picture.

The entire rectum is turned inside out, as one would turn a coat-sleeve, and presents a rosette of mucous membrane outside the anus, which after many descents becomes larger and larger, creating a true hernial bag of peritoneum and rectum, containing some of the pelvic viscera.

Appreciation of the anatomic fact can be had only when we recall that the rectum is a large pouch loosely attached to the sacral hollow and feebly suspended to the upper sacrum, by a mesentery, capable of the utmost relaxation under strain.

What really prevents normal descent of the rectum is the fibro-muscular floor of the bony pelvic frame—the levator ani muscles, which hold the viscera as in a sling. The outlet of this in the adult pelvis is the anal muscular canal, which has an axis pointing forward and upward, in a line which would emerge at the navel, and therefore nearly at a right angle with the sacral curve, which may be taken to represent the direction of extruding force. Practically, then, the musculature of the pelvic anus is designed in healthy adults to prevent any mishap such as occurs in the disorder we are speaking of.

In children, however, we have a shallow sacral curve, and loose network of tender areolar tissue stretching with great ease, and a young muscular development which under the weakening influence of disease and malnutrition gives way readily, and allows the easy descent of the bowel through the anal outlet.

Hence we see the great majority of cases of prolapse of the rectum in children of two, three, or four years, who have either been subject to prolonged whooping-cough, or weakened by diarrhea with tenesmus, and forced to use a vessel in defecation in the sitting posture, instead of the napkin while lying down; the prolapse, once occurring, stretches the already weakened muscle, which with the coincident wasting of peri-rectal fat allows the trouble to persist for a time even after health has been regained.

The unsightly rosette of mucous membrane often becomes an elongated and flabby tube several inches in length, soft, velvety, slimy to touch, not usually painful, but becoming so if long exposed, and swelling and bleeding if not reduced. This represents the entire rectal tube turned inside out.

In adult life we see the same condition much more rarely. It is about equally common in men and women. In men it is secondary to the

prolonged straining of constipation and hemorrhoids, or diarrhea and general weakness with incontinence; while in women it is more often seen as a sequel to lacerations of the sphincter in parturition, or in old enfeebled paralytics.

As noticed in the anatomic study, the posterior rectal surface is not covered by peritoneum, but in front the cul-de-sac of peritoneum comes down within reach of the finger introduced per anum. Hence when the prolapse is at all extensive there is a pouch of peritoneum forced out of the anus inside the anterior rectal wall. Into this, coils of small intestine readily fall, and the protuberant prolapsus then has a pine-apple shape, with point downward. In women the uterus, ovaries, and tubes may occupy this space.

Carelessness or inability to reduce this may often lead to drying and tough leathery change in the everted mucous lining, followed at times by excoriations.

Treatment of the prolapsus ani in children and adults is most successful on non-surgical lines, in the great majority of cases. The observing and patient physician will soon discover the cause, or combination of causes, which by correction will cure the trouble, and, once cured, it is eventually outgrown.

In adults a daily gentle laxative, cascara, compound licorice powder, pil. rhei comp., etc., with cool enema after defecation to restore tone to the anal muscle, will go far toward a cure. Add to this strychnin and electric stimulation to the fundament, with good diet and tonics, and the cure is complete.

In children the nurse or mother must speedily reduce the protrusion. She should place the child on the lap, face down, and by warm cloths, agreeable to the child, soothe and allay its crying, coupled with pushing in of the prolapse grasped by the four fingers, and anointed, pressing it firmly together so as to reduce its volume. The most effective way of curing is to prevent the extrusion. This has been demonstrated to be possible in almost every case by placing two narrow strips of adhesive plaster across the buttocks, holding them together, and supporting the anal muscle, but not preventing defecation if the movement is soft. Immediately after this act, the straps are to be removed, the parts cleansed, and the strap renewed. The tonicity of the sphincter and the general equilibrium of the supporting pelvic muscles is soon established when the strain has been removed.

It is rarely necessary to operate on prolapsus in children, inasmuch as persistent care will permit the child to grow to normal strength in these parts.

In adults the law of accommodation and adaptation also applies, if persistence in retaining a prolapsus is observed. In many cases it is possible to retain a rectal plug of vulcanite well in the rectum with a narrow stem in the anal grasp, and a smooth outside bar to press on the perineum, by a T-bandage and pad, so that after some weeks the natural tone is sufficient to maintain it. Cold or astringent enemata with tonics should be fairly tried. If, however, the case is obstinate, treatment by surgical means is called for.

Two methods have been proved efficient to meet every variety of prolapsus recti, no matter how complicated, and with comparative safety: First, the bloodless method, by cautery or acid; second, various cutting operations.

The method of choice among the non-operative is the *application of the Paquelin cautery*, or an old-fashioned small iron cautery heated by a lamp to a degree between cherry-red and black heat.

It should be used under anesthesia, and should be preceded by the same precautions as before other surgical work on the rectum, namely, three days of gentle intestinal purgation and a cleansing enema before operation. The bowel may be treated either when prolapsed or after reduction. In the latter case a relaxed sphincter will allow a rather large bivalve or wire retractor to be used in the lithotomy posture.

In either case the cautery is slowly drawn along the mucous membrane lengthwise of the bowel, at six lines, one-quarter inch wide from the anal margin upward, and at two or three points downward to the skin. This sears deeply the mucous membrane and heats the submucous layer enough to induce inflammatory exudate, but does not go deeply enough into the muscular layer to burn through.

An opiate suppository (aqueous ext. gr. 1) is then placed in the rectum and a rubber tube wound with iodoform gauze and smeared with vaselin is inserted. The bowels should then be kept constipated for five days or more, and the patient kept recumbent for ten to twelve days, all bowel movements being accomplished on the bed-pan. This method has uniformly been found efficient for permanent relief of prolapsus ani and many cases of rectal prolapse.

A simple cylindric speculum, with six lateral fenestræ, has been devised by Newman, of Glasgow, for linear cauterization of prolapsus, and used even in those cases where hemorrhoids are associated. The cauterized line begins a half inch above the skin top and effects a bloodless cure.

The surgeon of today will hardly return to the method advocated twenty years ago, of submucous injections of white oak bark or of carbolic acid, both of which can be resorted to with success in some cases, but always with a large risk of pyemic abscess.

Gersuny has resorted to his own wax injection to form a cylindric canal at the rectal outlet, but the method cannot safely be recommended to operators generally.

The linear cauterization by fuming nitric acid, or the application of the acid to the general surface of the prolapsed bowel, as recommended by Allingham (though used as early as the fifteenth century), is designed to set up a degree of proctitis resulting in contraction and fixation in the pelvis, but it seems less efficient than the cautery and somewhat more likely to produce destructive desquamation of the mucous coat. If used, the spread of acid along mucous folds beyond the intended lines must be checked, and care in drying up the excess, as well as liberal use of vaselin afterward, will be necessary to prevent serious sloughing ulceration, which has been known to cause stricture.

For the surgeon there remain numerous procedures from which he

must choose according to the case in hand: (1) Narrowing the anal orifice; (2) narrowing the ampulla; (3) amputation of the prolapsed rectum; (4) fixation of the reduced rectum by stitches in the sacral hollow; (5) intra-abdominal fixation (rectopexy and colopexy); and, finally, recto-sigmoid anastomosis and suture. Any one of these may be combined with another, or with cauterization, or with temporary artificial anus.

Narrowing the anal orifice would seem at first sight to be a *sine qua non* of success in preventing prolapse, hence we find attempts being made by early surgeons—Hey, 1788, Dupuytren and Dieffenbach—by excising a wide V-shaped piece of the orifice and suturing. It is probable that with prevailing suppuration and rare primary union in former days the results were not very good. The method has not been generally used, but Roberts distinctly claims success in excising not only a broad wedge of muscle but also a portion of the rectal wall above with the skin at the anus. Careful suture of the mucosa (the stitches to be thrown off on the rectal side) and of all the series of layers from muscle to skin by enduring catgut with retention stitches through the skin, fixes the tissues essential to good repair, until a solid anus is made. To this simple operation the surgeon may well bring his most careful technical skill, and only thus can he insure success. It should be no more difficult nor less successful than in similar reparative work on the anterior part of the perineum, where equally extreme prolapse occurs from high laceration of the rectovaginal wall and all sphincter tissue (see Fig. 94), and where excellent and permanent repair ensues. Retention silkworm-gut stitches must be kept in place on either side for not less than ten days.

FIG. 94.—RECTAL PROLAPSE WITH INTESTINES HERNIATED INTO THE POUCH.
Associated with prolapsus uteri and rectocele from lacerated perineum.

In lieu of a cutting operation Thiersch resorted to the *subcutaneous introduction of a silver wire* surrounding the anus, with a view of permanently replacing an inefficient sphincter. This is still used by some, and it is claimed to retain the bowel above, while not preventing defecation. Subcutaneous silk and kangaroo tendon have been substituted, but are probably less likely to remain aseptically in place.

A *plastic operation* to infold the wall of the ampulla was devised by Lange, who, through a posterior median cut from the coccyx to near the anus, divided the levator ani in the median line, dissected out the rectum from its loose cellular bed, and by a series of tier sutures reefed the baggy pos-

terior wall, so as to force the mucous surface into its lumen and narrow it to a relatively small tubular rectum. Cutting away some of the relaxed levator ani and carefully resuturing it, completed the supporting wall.

Attempts to *fix the rectum at a higher point* in the sacral hollow from which it slipped have been made by Verneuil, and repeated by Maury with a good measure of success.

The incision being made crescentic toward the anus and placed near the tip of the coccyx, the rectum is extensively loosened. Stitches of enduring chromic gut are passed well into its thick walls, and secured at a higher point in the sacral hollow, being brought out alongside the sacro-coccygeal border by a long curved needle with an eye at its end, which is thrust through the skin and draws the sutures to the surface, where they are tied over a roll of iodoform gauze and are retained for many days. This suspends the rectum long enough to secure good attachment. It is almost essential, however, to combine this with a circular kangaroo tendon or Thiersch silver anal suture to insure good results.

Amputation of an inveterate prolapse is often demanded and has many advocates. Mikulicz and Treves regard it as perhaps the best resource we have in many cases. It has the indorsement also of Nature herself, a bungling surgeon often, but good at repair. It has occasionally happened that the grasp of a tight sphincter has strangulated a prolapsed rectum, and, the slough having come away, a cure has resulted. In imitation of this Mikulicz offers a technically correct method.

The operator must keep in mind the occasional presence of coils of small intestine in the peritoneal pouch in the front part of the hernia, and that he must in any event open the peritoneal cavity in resecting the bowel.

Grasping the prolapsed part with a cloth, a cut is made across the front of the mass, a fingerbreadth or so below the anal margin. Cautiously opening the peritoneal cavity, any pelvic viscera are returned, and the clean peritoneal surface approximated, using a continuous quilt stitch to suture the cut edge of the outer tube to the outer wall of the inner. This arrests hemorrhage without independent ligation of vessels. Carrying the incision entirely around the prolapsed outer tube, there remains only to amputate the mass by cutting the inner tube off at the same line, and suturing the two cut mucous edges. The cleansed stump is returned, and the short rectal tube thus created should be protected from resuming its function for a week or so.

Modifications of Mikulicz's method have been offered by Mathews, Kleberg, Fowler, and others, but none can exceed in safety and perfection the one described.

It remains to describe the latest and perhaps the best method yet devised to hold the rectum up, namely, the *rectopexy* or *sigmoidopexy* suggested by Hutchinson and Allingham in 1880; and adopted with modification by McLeod, Berg, Cady, Jaennel, Garrè, von Eiselsberg, Bryant, and now generally by surgeons.

After Waldeyer's demonstration that prolapsus generally begins by downward visceral pressure from above in the peritoneal cul-de-sac (rather than by dragging from below), it seems rational to support the

rectum or rectosigmoid mesentery by stitching it to the abdominal wall through a laparotomy wound.

Operation.—With the patient in the Trendelenburg posture the pelvis should be emptied of intestines and traction made on the sigmoid; this will draw up the prolapsed anus. Then it will be seen that catgut or silkworm-gut can be used to suture its mesentery to the parietal peritoneum, either in the pelvis or at its brim, or for some distance upward on the parietes of the abdomen. Subsequent inflammation will surely fix it there, much as it suspends a retroverted uterus.

It is capable of demonstration that, in operating thus through a laparotomy wound, if the prolapsus has not been reduced before operation, traction made on the loose sigmoid and rectum will of itself cause the procident gut to be drawn back to its normal position in the sacral hollow. The surgeon who tries to lift the rectum in a normal pelvis by traction on the sigmoid will observe that he pulls only on the mesorectum about the sacral promontory. Thus he demonstrates the important cause of prolapsus, namely, complete relaxation of the suspensory tissues. This defect, therefore, is the point of attack in the method now to be adopted. The essential element of success will depend on whether the suspended bowel can be so secured that we may hope for permanent benefit.

Experience shows that this can be done by regarding in each case the abdominal conditions of relaxation. In operating a left lateral abdominal wound should be made, and it should be fairly liberal, as its strength can be restored by immediate suture of all layers, and circumstances may require ample room for deep and careful suturing.

The sigmoid being followed down to a point where traction produces the desired reduction and support, its mesentery or its thick anterior muscular wall is to be united by liberal use of silkworm-gut or chromic gut (or silk, if the operator prefers) to the internal surface of the abdomen, each stitch taking hold of firm subperitoneal structures, if permanency is to be hoped for. This may wisely be preceded by sutures at the pelvic brim fixing the mesorectum.

The greater facility of working in the pelvis through a median wound makes this desirable, and has led to the modified method of suspending the rectosigmoid junction to the median abdominal wall, thus bisecting the pelvic cavity, and in cases of combined uterine and rectal fixation to the abdominal wall; this has been secured after the usual hysteropexy method.

It has been advocated by Jaennel and others, in view of the concomitant dysentery not infrequently seen, that a temporary artificial anus shall be made, to give rest to the parts. This is unquestionably sometimes a wise surgical step. Bryant has observed a tendency to recurrence of prolapse as the artificial anus closes. As it is desirable, however, to insure primary union, without contamination of the wound, when main dependence is to be on the suspending force, it will be unwise to take this step in most cases. One would fear that a fixed sigmoid might produce obstruction, but this has not been proved to be a menace in any case yet reported, and doubtless the sigmoid adapts itself as a containing pouch, with ample relief through its large caliber.

Experience has shown that it is necessary to perform secondarily one of the minor surgical plastic operations on the relaxed anal portion of the rectum after suspension from above, so as to cure the still recurring anal prolapse of mucous membrane.

It is evident that very bad cases of prolapse will be ineffectually treated at times even by suspension, and recurrence will follow, so that even more extreme measures must be taken. Von Eiselsberg in exceptional cases resects the sigmoid flexure and anastomoses the drawn-up rectum. Ludloff recommends anastomoses of the sigmoid end cut off to the side of the rectum. This will appeal to operators accustomed to do intestinal anastomoses as feasible and effective in giving fine rectal support, and a straight channel from the colon to the rectum, especially as the sigmoid end of the lower segment is to be closed and fixed to the abdominal muscle.

Even after the employment of these severe measures some recurrences take place, and it is evident that a strong mechanical sense on the part of the surgeon, with a full knowledge of the value of intraperitoneal adhesions, with serious study of each case, will be necessary to secure adequate help.

The ultimate results of rectopexy and sigmoidopexy have been studied by Pachnio from fifty-eight published cases, of which twenty-two only had been watched more than a year; of these, thirteen (nearly 59 per cent.) recurred. Of eleven cases done at Garrè's clinic in Königsberg since 1901, 54 per cent. recurred.

The final results of colopexy are so far dependent on subsequent care that statistics give little proof of the real value of this method, since few hospital patients are able to maintain long convalescence, or to carry out the principle of evacuation of the bowel in the recumbent posture, so much to be insisted on after all operations for prolapse. Nevertheless; the principles laid out in the above method must always guide the surgeon, and his enduring success will depend on restoration of his patient's health on broad lines of convalescence.

Hemorrhoids.—Hemorrhoids and hernia represent perhaps the most wide-spread afflictions to which man is heir; and both are fortunately today capable of radical cure with an infinitesimal risk.

The term hemorrhoid is applied to a soft tumor at or within the anus, consisting of a spongy, highly vascular mass, which may bleed easily and profusely. Its name signifies a "flow of blood," and its greatest peril to the sufferer is in its frequent and liberal bleeding, which often exsanguinates the patient. It is almost unknown in children, but between puberty and old age it is extremely common. It presents itself in every degree of severity, under practically two forms—external to the anus and internal.

External hemorrhoids consist of dilated varicose veins around the anal margin buried beneath the skin and external to the sphincter muscle. There is also a kind of false external hemorrhoid, a fringe of tabs of pendulous skin, often half an inch to an inch in length, which is sometimes included in this term, but which is in no way related to antecedent or future hemorrhoids, being simply redundant skin not containing veins. These

should not be designated hemorrhoids, as they can be cut away with almost a dry base.

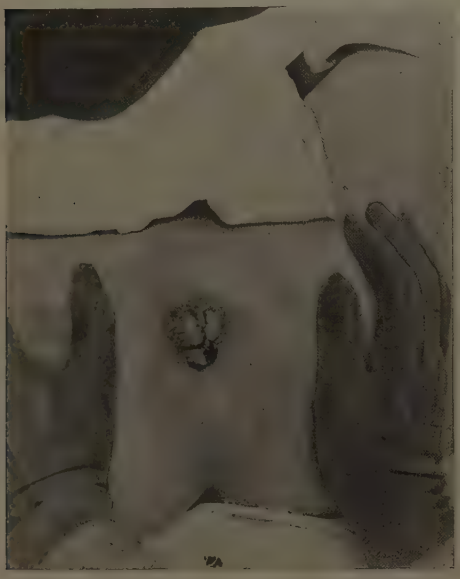


FIG. 95.—EXTERNAL HEMORRHOIDS.

The true external hemorrhoid, however, is dusky purple, and sometimes covered by fairly thick skin. It can be distended by the patient's holding his breath and straining down. Then it becomes turgescent, and if several exist, they form a tumid ring, with a marked sulcus above, defining the circle of mucous membrane which is drawn down between the two sphincters. This venous chain is almost wholly emptied by the ascending series of the inferior and middle hemorrhoidal veins into the iliac veins and the vena cava; while those which are above this line discharge by the superior hemorrhoidal into the portal vein and enter the system through the liver. External hemorrhoids are seldom very large, though by their distention of this sensitive anal membrane they often provoke itching, and by being subject to marginal scratches and cracks from hard fecal movements are very likely to show a slight blood stain, rarely severe, at defecation.

FIG. 96.—EXTERNAL THROMBOSED HEMORRHOID.

A *thrombotic hemorrhoid* is quite common, and consists of a hard blue subcutaneous or submucous tumor, about the size of a white bean, almost always single, appearing suddenly outside of the anal ring, and due to distention and thrombosis of an inferior hemorrhoidal vein. It has been wrongly called an apoplectic hemorrhoid, but it is not due to a rupture of a venous wall. The sacculated vein must become distended and then suddenly fill with solidified clot. If let alone, it slowly absorbs and leaves a fibrous remnant. If incised,

the operator turns out a bean-shaped clot and the sac collapses and heals.

It may be most painful, owing to the tension of the sac, and will be relieved only by cutting, or by waiting many days for absorption. It is practically a phlebitis under tension, hence the pain.

Internal hemorrhoids are spongy tumors formed in the mucous and submucous areolar tissue covering the internal sphincter muscle. Their substance consists wholly of an angioma with hyperplastic areolar tissue, covered by mucous membrane.*

Often the dome of the pile is denuded so that a raw bleeding surface presents, which when turgid from straining or rasped by passing movements freely pours out blood. This may weep from the whole granular face, or be seen pumping from one or more open vessels.

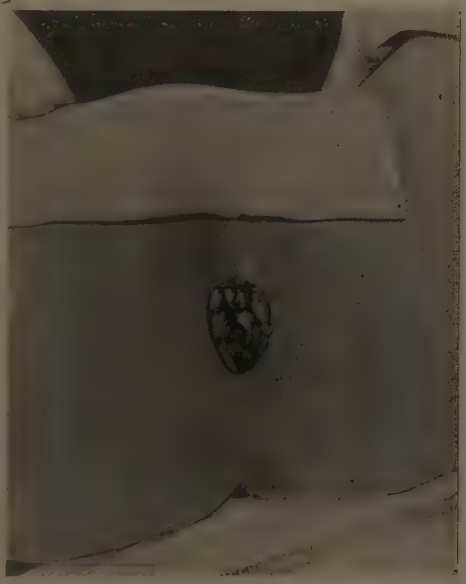


Fig. 97.—Internal Hemorrhoids.
Same case as Fig. 95, after stretching of the sphincter.

If the bleeding surface is not underlaid by a tumid mass of considerable size, it may be called a capillary hemorrhoid. When infection enters the raw surface of the hemorrhoid or when thrombophlebitis affects the angiomatous substance of the pile, it takes on a solidification which is always easily felt when reduced. Varying degrees of density characterize this type. Study of hemorrhoids by injection through arterial or venous channels shows that there is always one main arterial supply coming down under the mucous membrane in the axis of the bowel, a branch of the superior hemorrhoidal. The congeries of veins constituting the mass are tortuous, dilated, and varicose, and are held in a definite capsule by a network of cellular tissue.

The artery, as emphasized by Allingham, can always be felt by an examining finger, and for an operable pile is often as large as the radial artery. Nevertheless when the hemorrhoid is reduced within the sphincter, it so far empties its veins that there remains oftentimes nothing which the palpating finger can feel. Only after inflammation has set up thickening in older varieties can the hemorrhoid be felt. It can always be seen, however, through a speculum, or when the patient protrudes it by straining after an enema. It frequently happens that a patient suffers from

* With a history of protrusion and bleeding the physician will secure a demonstration of them by having the patient strain in the squatting posture after an enema.

intermittent prolapse of one or more piles, but cannot exhibit this on the examining table.

Extruded at stool, it is held outside the sphincter and becomes more turgid, inflamed, and extremely painful. Such a condition is more or less sudden, and is called an "attack of the piles" by those who have more than once experienced it. While not serious, it usually requires from two to ten days of rest and treatment to become quiescent. The patient is usually seen in great pain, of an intense aching and neuralgic type. The sphincter takes on spasmodic action, and whereas the patient has heretofore easily reduced the protrusion whenever it has been out, neither he nor the physician can now do so in many cases. Edema and lymph infiltration of the base, as well as the thrombophlebitis within the substance of the hemorrhoid, make a painful mass, the handling of which the patient will not tolerate. Retention of urine is quite a common coincidence. Surface application of cocain is but a partial relief, for few things are more painful than the inflamed wall of a vein in this or in any part of the body.

Reduction.—Operation during this stage of inflammation is not generally sanctioned, as the resulting ulcerated surface seated on an infiltrated base is large and slow to heal. There remain, therefore, two things to do: either reduce the mass under anesthesia, or palliate the symptoms until resolution has taken place. The tumid mass, which is often quite large and hard, can sometimes be reduced with or without general anesthesia and dilatation of the sphincter, but it tends to slip out again easily, on account of its having embedded itself in the intersphincteric area. If, however, it can be kept in for a few hours it will reduce the convalescence to one or two days, though an aching may persist in the fundament even if a pad and T-bandage retain the hemorrhoid.

Inability to return the mass requires palliative treatment—a hypodermic of morphin or a suppository of opium, with cleansing of the mass by boric acid wash and a wet compress of lead and opium lotion or a small ice-bag. An attack of inflammation such as described does not cure the hemorrhoid, as one might hope.

The cause of hemorrhoids has been variously ascribed to plethora from overeating, constipation, diarrhea, sedentary habits, long sitting at stool, venous obstruction, such as accompanies cirrhosis of the liver, tumors of the abdomen or pelvis, too constant use of cathartics, arduous work in standing postures, like that of drivers, and many other causes associated with individual cases, but it is only in the very exceptional case that people given to such occupations are victims of hemorrhoids.

It seems probable, therefore, that mechanical pushing down of the lower mucous membrane of the bowel by chronic constipation, with prolonged sitting during the act of defecation, is the most reasonable and commonly associated cause.

Symptoms of chronic hemorrhoids are wanting unless protrusion occurs, or when the pile remains outside, as occasionally happens. Bleeding is seen in the majority of cases when piles are prolapsed, but in non-prolapsed cases it is usually shown during straining, or seen on toilet paper

after the movement. Exceptionally a pile which has been denuded of epithelium will bleed at each movement, several ounces, and stop only when the hemorrhoid is drawn within the sphincter. This type, however, is apt to lie close upon the border of the muscle and slip out at inconvenient times, when walking, coughing, sneezing, or in public speakers or clergymen during active speaking in the standing posture, when blood may be felt trickling down the limbs, associated with the conscious discomfort of the protrusion.

If the hemorrhoid has become tough in quality and does not bleed, it may remain much of the time outside the sphincter, yielding a mucoid or lymph exudation to stain the clothing and irritate the skin.

Hemorrhoids complicated by fissure or occasionally fistula may present all the attendant symptoms of those conditions, but in themselves, when kept internal to the rectum, they yield no marked symptoms, if not inflamed.

Treatment.—The palliative treatment of hemorrhoids should be kept in mind by the surgeon, inasmuch as the majority of moderate sized hemorrhoids can be so far cured as to avoid operation by strict attention to hygiene and dietetics. Errors to be corrected are costive habit and long straining, overeating, excessive smoking, lack of walking exercise, and rectal tenesmus from fissured mucosa.

A systematic use of mild laxatives (rhubarb pill at night, a mild mineral water on rising), a cool cleansing enema after action daily, strychnin tonic, and moderate physical exercise will after a few weeks usually relieve the hemorrhoidal engorgement and restore tone to the parts so that infrequency of protrusion will be followed by complete retention.

Operative Treatment.—A great variety of curative methods have been offered and discarded. Many possess an unwarranted measure of risk; others are inefficient except in mild types of disease. Surgeons of the largest experience have narrowed down the operative procedures to two or three, and they will be described in order of their acceptance.

First in surgical esteem is unquestionably *Allingham's method of excision and ligation.* It presents practically no risk if done with reasonable skill and yields a lifelong cure. The principle on which it is based is that one nutrient artery supplies each pile, and that it descends into it close under the mucous membrane.

Excision of most of the tumor until it is attached only by a pedicle above, in which is the artery, ligature of this pedicle, and cutting away the tumor, leaves the cut mucous edges to fall together and healing is rapid, with an insignificant scar, which after a while is invisible. This operation has now been done many thousands of times without mishap, and if care is exercised may be said to present the most insignificant risk. It has been modified by suturing the cut edges, but this is wholly unnecessary, and may tend to confine exudates from the cut surface, as well as adding to the time of operating. In its simplest form it constitutes one of the quickest as well as the safest methods known.

The details of operation are, first, two days of laxative preparation and an enema to cleanse the rectum before operation. Second, etheriza-

tion and the lithotomy position, knees secured well flexed on the abdomen, the hips being raised on a hard pillow. Third, thorough stretching of the sphincter, to allow protrusion of the hemorrhoid. Fourth, identification of the number of individual tumors presenting. This is not always easy, for while there may present three, four, or five swollen masses, looking like the tips of the fingers of one's hand grasped by the thumb and index of the other hand, they may appear as a conglomerate mass with elevated mucous membranes stretching from one to the next. The operator then singles out two or three conspicuous individual piles and fixes a clamp upon the rounded top of each, grasping enough to comprise half its bulk. These being drawn down and held aside, the remainder will define itself, and its artery can be felt above, which indicates the hemorrhoid. At least one good assistant besides the anesthetizer is essential.

FIG. 98.—ALLINGHAM'S OPERATION FOR INTERNAL HEMORRHOIDS.

The instruments needed are few; a half dozen artery clamps, a pair of blunt curved scissors, ligatures of catgut, and a rubber tube, pencil size and four inches long, wound with iodoform gauze to the size of one's little finger, constitute the essentials. Two narrow flat retractors may be needed occasionally, but when the anus has been well dilated all the work is done outside the anus, owing to traction on the clamps everting the hemorrhoidal region.

Each pile should be cut as follows: the series of clamps on separate tumors being held aside by an assistant, one clamp is taken by the operator and the pile drawn upon slightly. The radiating fold of mucocutaneous border is then snipped through by the scissors rather deeply, and the pile proper is then raised from the muscular bed. A second cut, close to each side of the clamp, separates the hemorrhoid without loss of much mucous membrane. The scissors now pressed beneath the mass loosen it and narrow the pedicle above, which may be again snipped on either side so as to leave only a strip of mucous membrane underlaid by the artery, and located on the upper sphincter. This pedicle is now ligated tightly by catgut or silk, and the other part of the hemorrhoid is cut off, leaving a long pedicle to atrophy.

From one to five such tumors may be quickly removed in this way. The two most important precautions in the operator's mind are to leave

a wide strip of mucous membrane on each side of each pile, at the anus, and to ligate tightly the pedicle, which is to be cut long. When all the piles have been removed, it is seen that the cut edges fall together in lines corresponding to axial folds, and need no suturing. A suppository of 1 gr. aq. ext. opium is now inserted in the rectum; and the gauze-wound tube, well annointed with vaselin, is pressed into the bowel so as to present its inner end above the sphincters. Its rough surface maintains the coapted cut edges in absolute fixed position during the four days before its removal.

FIG. 99.—RUBBER TUBE WOUND WITH IODOFORM GAUZE, INSERTED AFTER ALLINGHAM AND WHITEHEAD OPERATIONS.

The operator will wisely adjust the mucous edges after the tube is in place, and if they are not sutured the cut cellular planes will drain into the gauze, and give primary union. The tube has a threefold value: as a "tell-tale" to notify of any hemorrhage after operation; as a vent for escape of flatus; and as a means of giving entry to a simple enema on the fourth day. The enema being administered, the tube end must be bent or tied, to retain the fluid, and after a few moments, evacuation takes place and blows out the tube with it, often unconsciously to the patient.

FIG. 100.—HEMORRHOIDS. TREATMENT BY CLAMP AND CAUTERY.

Venous hemorrhage in this operation always stops spontaneously. The arterial is from the descending hemorrhoidal only and never gives trouble if tied in the pedicle as above.

This operation, then, has probably the foremost place in surgical appreciation today.

Second to it may be placed the *clamp and cautery method*, which has some advantages making it the preferred operation in the work of many.

Operation.—The same preliminaries having been adopted, the protruding hemorrhoids are seized, one at a time, and held up by a clamp while the main portion of each is caught in the bite of a flat crushing clamp, so devised as to screw together at the handle and act as an angiotribe. This narrows the base of the pile to a linear mass, and if left in place only a few moments would probably, of itself, so crush the artery as to produce occlusive endarteritis. But the operator does not rely on this possibility. A certainty of cure is obtained by cutting off the greater part of the pile, leaving a narrow strip on the face of the clamp, which is burned down to a tough remnant by the cautery, which in itself creates an aseptic surface, and coagulates and obliterates the vascular stump. This stump, when released, retains its linear form and returns to the rectum in an axial fold.

The cutaneous margin ought not to be caught in the clamp, as the essential part of the pile is above, and the burned skin may be subsequently more tender.

The same number of hemorrhoids may be treated by this bloodless method as by ligation, and it has the merit of simplicity and bloodlessness. Its one risk, perhaps, is in the possibility of post-operative hemorrhage, from reopening of the crushed stump, which in the hand of a careful operator is extremely small; yet for all surgeons there is no security equal to the ligature.

After clamp and cautery removal a suppository of opium, and the introduction of a small gauze-wound tell-tale tube, facetiously called by house surgeons "the whistle," are essential. Evacuation of the bowels should be left until the fourth day or later, when the vessels will be securely sealed and the scar healed enough to hold together.

By this method the patient can be allowed to get out of bed and attend to business in a week—somewhat earlier than by Allingham's method.

Whitehead's Method.—When there are four or more large hemorrhoids with ill-defined borders, the entire pile-bearing area represented by the circle of mucous membrane underlaid by the upper part of the sphincteric ring seems to have slipped down and protruded like a prolapsus when the muscles are stretched.

Instead of removing the tumors separately, each with a considerable covering of mucous membrane, creating a risk of anal stricture from denudation of the anal outlet, Whitehead, of England, advocates amputation of the entire tube of mucous membrane and suture of the upper cut edge of the skin.

The operation was widely adopted for many years, but it is now generally reserved for very bad cases of prolapse with many piles, inasmuch as a little skill enables any operator to single out three to five major tumors from the prolapsus ring, and by clamp and cautery or by ligation so far relieve the mass that after reduction the whole area contracts and remains cured. Nevertheless the Whitehead method can be skilfully and speedily done, and has decided advantages.

Steps.—In its simplified form the steps are as follows:

The same preliminaries as to preparation and position being made the surgeon stretches the sphincter and places five or six ordinary hemostatic forceps upon the protuberant hemorrhoids. A knife incision at the junction of the skin and anal mucous membrane is now made surrounding the anus.

An assistant holding the clamps, the operator grasps the mucous border with toothed forceps, and by scissors strips it away from the external sphincter all round. The blunt scissor end then separates the inner mucous layer readily at a higher and higher level by blunt dissection alone, with little or no hemorrhage. Traction on the clamp meanwhile easily draws down the cylinder of mucous membrane bearing the hemorrhoids.

Fig. 101.—Whitehead Resection of Hemorrhoidal Area Partially Completed.

It is now apparent that the upper mucous border can be stitched to the skin, and a half-inch cross-cut is made to begin this at the midperineal line. A straight Hagedorn needle armed with medium catgut is used for continuous suture round the entire bowel. The operator begins to cut off the bowel at the middle line in front, and by cutting half an inch or more at a time, divides the arteries of the submucous coat one at a time. The bleeding would be severe if the needle were not promptly passed through the opposed gaps so as to engage the open-mouthed bleeding vessel and grasp it. This always stops hemorrhage at once, without the need of applying separate clamps and ligatures. Thus it is easy quickly to suture the edge of the entire amputated prolapse to the skin, without tying any vessel. This shortens, simplifies, and makes comparatively bloodless a method which if carelessly done may be a tedious and troublesome one.

Independent sutures are placed by some about the line of union, but this increases the time of operation and does not secure the bleeding points as well as a continuous suture.

The attractiveness of this method is increased by having the line of union at the circumference and not within the bowel, where contact with the outer part of the iodoform gauze-wound tube insures clean primary union.

The one weak point in the operation is the possibility of retraction of the wound edges if too soon disturbed. Hence the first movement by enema should be delayed until the fifth to the seventh day, when union is firm. If the skin line separates, a quarter inch of granulation may

require tedious repair and result in stricture. This, however, will yield to gentle dilation.

Many simplified methods have been tried in hopes of avoiding the trouble and supposed risk of the methods just described; but they have attraction only for the practitioners of medicine who do little surgery, and for the itinerant, who seeks patronage for bloodless methods.

First among these to be condemned for general use is the *injection of carbolic acid.* It is attractive because of its simplicity, but dangerous because, more than any other, it has a risk of pyemia and hepatic abscess. Many patients have fallen to the care of practitioners, and have died pyemic, of whom the advertising quack never heard after he made his carbolic acid injection. Nevertheless the method has a value in certain cases in which anesthesia cannot be borne, and where the patient may be willing to take some risk for the cure obtained.

The pile must be well extruded, washed with an antiseptic, and held from retreat by a finger inserted within the sphincter. The needle of a hypodermic syringe filled with carbolic solution, 10 per cent. (in half glycerin and water), is pushed to the center of the pile and five or six drops inserted. The pile swells, and whether the distended veins or cellular interspaces receive the fluid the operator cannot know. He smears the pile with vaselin before operation, and on withdrawing the needle returns the mass, now much firmer, in beyond the grasp of the sphincter.

There is probably an albuminous coagulation of the blood in the pile, with subsequent cellulitis and thrombophlebitis, sealing it up for good. Most surgeons have occasionally resorted to this method when called for, and with strict watchful care, patients have escaped without accident. As a routine treatment, however, it is to be condemned, inasmuch as, if abscess forms in the mass, as has often happened, there is no way of controlling the portal infection, which causes pyemia beyond surgical aid.

At one time it was believed that simply *stretching the sphincter* was competent to cure hemorrhoids, but, except in some very simple types, it has been found insufficient. So also pinching up of the mucous membrane of the top of each pile and ligating with a bit of silk was thought to be enough to excite deep enough cellular inflammation to solidify the mass. This, too, has been wholly abandoned.

Ignipuncture with a point of cautery, simply penetrating the hemorrhoid, will in some cases happen to obliterate the vessel, but may excite bleeding from the puncture wound or beget secondary suppuration or be wholly inefficient.

TUMORS OF THE RECTUM AND ANUS.

The tumors of the rectum do not differ greatly in their characteristics from those of other portions of the gastro-intestinal tube; tumors of the anus also correspond in structure to the growths arising from squamous epithelium in other portions of the body. The most striking clinical differences noticed between growths in the rectum and those occurring elsewhere are due chiefly to the anatomic conditions under which the tumors

are placed. Among these conditions may be enumerated, first, the presence of the tumor in a tube surrounded by a fairly impermeable muscular and fibrous tissue wall, which, to a certain extent, prevents the extension of the growth by contiguity, metastases generally taking place by direct extension along the very abundant lymphatics which are present in the submucosa (Fig. 102); second, the position of the neighboring lymph-nodes in the pelvis may be considered as influencing metastases of rectal growths. The close anatomic relationship which exists between the rectum and the organs directly anterior to it, such as the vagina, bladder, and prostate, also give scope for either secondary invasion of these organs

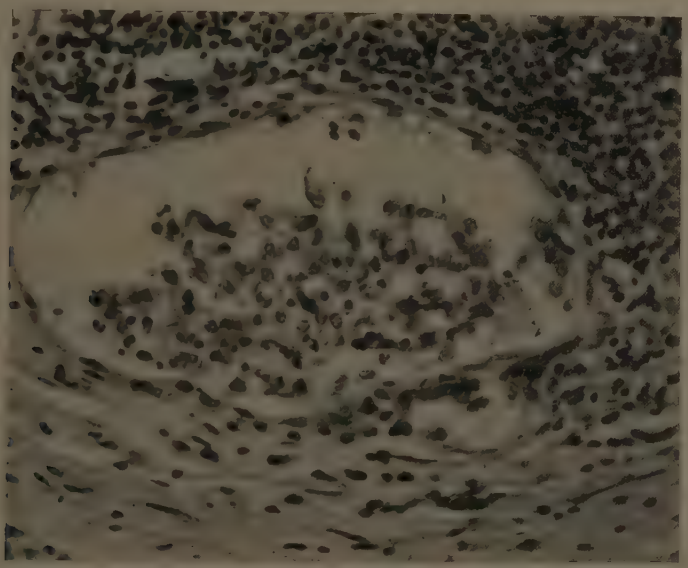


FIG. 102.—SECTION OF LYMPHATIC VESSEL IN SUBMUCOSA OF RECTUM, SHOWING MASS OF CELLS FROM A CARCINOMA (× about 250 diameters).

from the rectum, or secondary invasion of the rectum by tumors arising in any of these organs.

A consideration of a few points in regard to the anatomic position of the rectum itself and of the pelvic nodes may therefore be of interest.

If we accept the definition of Sir Frederick Treves, by which the sigmoid terminates at the level of the attachment of the mesentery in front of the third sacral vertebra, there is but a small portion of the rectum which is intraperitoneal, and this free surface is ventral, forming a portion of the posterior wall of the rectovesical pouch, or, in the female, the cul-de-sac of Douglas.

The mucous membrane of the rectum is composed of a series of deep and narrow follicles lined with high cylindric epithelium, the crypts of Lieberkühn. Many of the epithelial cells contain more or less mucus, especially when a chronic inflammation is present. There are also a few lymph-nodules embedded in the mucosa.

The terminal 2.5 cm. of the canal forming the anal portion is lined with stratified epithelium and has no glandular structures.

The abundant lymphatics with which the rectum is supplied form two groups, one of which arises in the mucous membrane as an extensive plexus in the submucosa, while another and smaller system lies in the muscular coat. The connecting trunks coming from the wall of the rectum unite to form a large hemorrhoidal lymph-trunk, and terminate in lymph-nodes lying in the course of the middle hemorrhoidal artery some distance from the lateral wall of the pelvis. These trunks finally drain into the sacral group of nodes. There are also numerous small secondary lymph-nodes along the course of the hemorrhoidal vessels. Other groups of lymph-channels pass to the lymph-nodes lying in the mesorectum and there communicate with a series of nodes lying as high as the promontory of the sacrum. The channels also communicate laterally with the group of nodes lying close to the external iliac arteries. Other branches pass forward and anastomose with the lymphatic channels about the prostate or in the broad ligament of the female.

Fig. 103.—Longitudinal Section of Small Anal Fibroma (× 30 diameters).

Some of the lymph-vessels from the anus pass upward through the fatty tissue in the ischiorectal fossa, and after penetrating the levator ani, terminate in a node near the origin of the internal pudic artery. Another group of lymph-channels passes forward over the anterior aspect of the thigh and ends in the superficial inguinal nodes. Other branches pass over the perineum and go to the hypogastric lymph-nodes lying along the internal iliac vessels.

The most frequent metastases seen in connection with rectal tumors are in the walls of the gut itself or the nearby sacral lymph-nodes. Metastases at a distance are not frequently met with.

Benign Tumors.—The benign tumors which occur in the rectum and about the anus may be divided into several groups, depending upon the tissues which they contain.

Fibromata are of infrequent occurrence about the anus in adults. They are composed of dense fibrous tissue containing a few small blood-vessels and nerves, the whole covered with a thin layer of epithelium (Fig. 103). Such polypoid growths are probably in many cases only

atrophic hemorrhoids. They cause no symptoms and are unimportant clinically.

Papillomata are occasionally met with in the anal region. They correspond to similar tumors found elsewhere and have no etiologic connection with venereal disease. They do not differ in their structure from papillomata elsewhere. Papillomata developing in connection with specific and non-specific processes are called condylomata.

Condylomata, which are frequent about the anus, are usually classified in two groups, the flat and the pointed condylomata. The flat condylomata are broad, flattened, sessile tumors, consisting of connective tissue covered with epithelium. The surface is irregular and the epithelium is usually thin and much macerated by the secretions of the parts. Occasionally extensive ulceration occurs. The epidermal layer is extensively infiltrated with leukocytes, and frequently covers the connective tissue but imperfectly. The same infiltration with leukocytes is seen in the subepithelial connective tissue. Such growths are frequently of large extent, and are most often seen in connection with active syphilis. The pointed condylomata form small wart-like masses consisting of projecting connective-tissue papillæ, carrying some blood-vessels and covered with a thick layer of epithelium. Both the epithelium and the connective tissue of the papillæ and the pedicle of the growth show a round-celled infiltration with swelling of the vascular and lymphatic endothelium. They are usually seen in connection with chronic inflammation of non-specific nature or of gonorrheal origin. While these papillomata usually remain small, they may form masses 4 or 5 cm. in diameter.

Adenomatous new-growths of the rectal mucous membrane are the most frequent of the benign tumors of that organ and are especially frequent in children. These adenomata may be single or multiple, and may be sessile or possess a long pedicle, forming the so-called rectal polyps (Fig. 104). These polyps may either be villous, or form small, fairly smooth, nodular, firm masses. In both cases the growth is due to a hyperplasia of the glandular tubules of the mucosa, the formation of the pedicle being due in many cases to the looseness of the submucous coat and the dragging of the tumor on the mucous membrane. Microscopically these growths show an extreme hyperplasia of the glands of the rectum, chiefly of the deeper portion of Lieberkühn's crypts. A good deal of mucus is usually produced in the tubules and may give rise to cyst formation. The hyperplasia of the epithelium of these rectal polyps usually remains within the limits of normal tissue growths, but occasionally the cellular proliferation becomes more active and the tumor assumes the type of adenocarcinoma. It is often difficult, however, morphologically to separate the two. Some of the simple adenomata apparently recur as carcinomata, though the morphology of the original growth may not suggest malignancy. Occasionally, also, carcinoma of the rectum may be associated with multiple adenomata of the intestinal tract not of a malignant type (Hauser). The size to which these polyps may develop is variable. Usually they are small, often not over a centimeter in diameter.

Not infrequently they may reach the size of 4 or 5 cm., and very much larger tumors have been seen.

Other tumors of the benign type are found in the rectum, but are of great rarity. Among these may be enumerated **lipomata,** which usually form in the fatty appendices of the upper portion of the rectum, but may project into the lumen and cause invagination or prolapse of the gut. Occasionally, such tumors have been found free in the pelvis, the pedicle attaching them to the gut having ruptured. They often contain a considerable proportion of fibrous tissue and may be properly designated as fibrolipomata.

Another rare tumor is the **myoma** or **fibromyoma.** These growths spring from the muscularis of the intestine, chiefly from the longitudinal layer. They consist of smooth muscle-fibers and fibrous connective tissue in various proportions. They may project outward or inward. In the latter case a pedicle may develop, giving rise to a polypoid myomatous growth. Under such circumstances, however, the surface of the tumor is covered with mucous membrane, and it is not always easy to separate them from the true polyps of the rectum.

FIG. 104.—RECTAL POLYP.

The tumor was of benign nature, and was composed of hyperplastic mucous membrane.

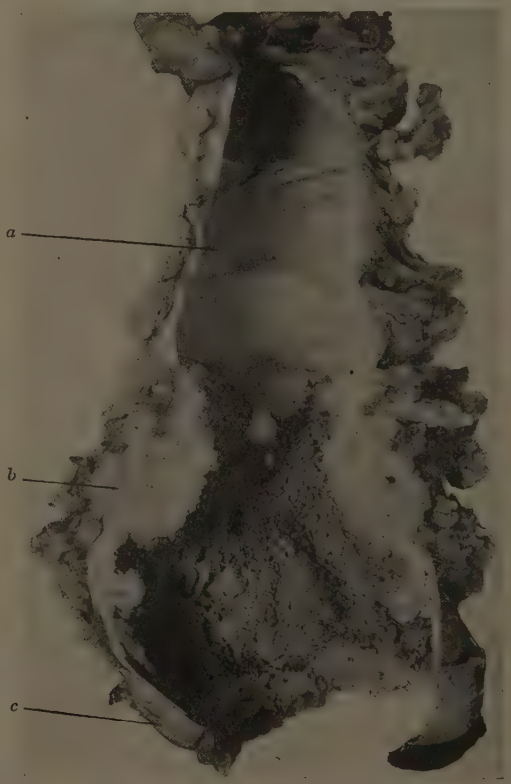


FIG. 105.—COLLOID CARCINOMA OF THE RECTUM, ANNULAR FORM, SITUATED ABOUT 5 CM. ABOVE THE ANUS.

a, Dilated atrophic upper portion of rectum; *b*, new-growth involving all the coats; *c*, beginning of anal portion of rectum.

Angiomata have been described. They are merely flat tumor-like masses whose substance is chiefly composed of dilated capillaries.

Malignant Tumors.—Epithelial Group.—Carcinoma of the rectum

is frequently seen, forming a considerable proportion, usually estimated at three-fourths, of the tumors of the intestinal tract. Usually the growths retain an adenomatous type with a diffuse growth of tubules lined with cylindric epithelium. These tubules and the cells lining them vary but slightly from the normal tissues of the rectum, and the determination of the malignancy of the tumor often has to be made upon the penetration of the submucosa of the rectum by the new-growth. Other more aberrant types are, however, not infrequent, and medullary, gelatinous, and scirrhous carcinoma may be seen. The growths may be situated in any portion of the rectum; usually they are present either in the lower portion just above the anus, or in the upper portion near the sigmoid. They may occupy only a small portion of the wall of the gut as a flat plaque; they

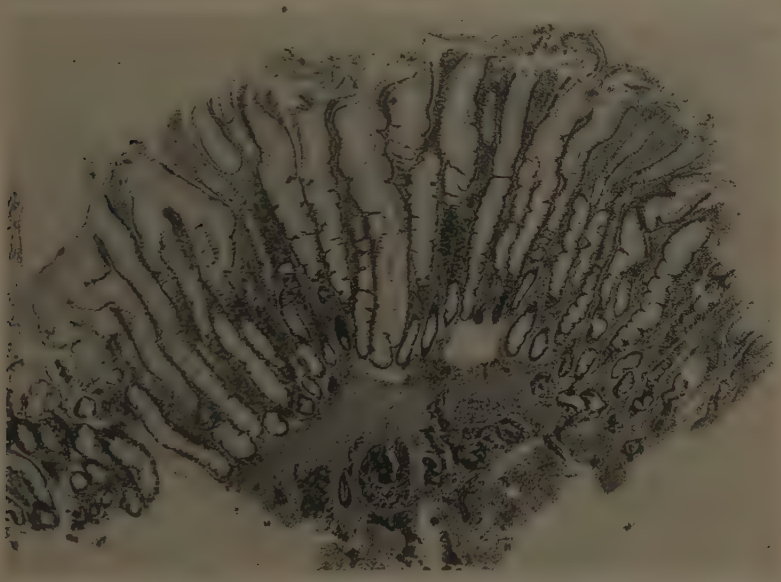


FIG. 106.—SECTION OF WALL OF RECTUM SHOWING INVASION OF THE MUSCULARIS BY NEW-GROWTH ABOUT 10 CM. DISTANT FROM THE POINT OF SECTION.
The mucous membrane shows the lesions of chronic catarrhal colitis (× 25 diameters).

may involve large portions of the tube on one surface only, or they may form cylindric masses entirely encircling the lumen (Fig. 105). The inner surface of the growth is usually rough and irregular and bleeds very easily, and the superficial portions frequently undergo extensive necrosis. If the necrosis becomes very extensive, a proliferation may occur, with the formation of fistulas between neighboring hollow organs, such as the bladder or vagina.

A small tumor at one point may give rise to extensive infiltration of the submucosa or muscularis or of a large portion of the muscularis above and below it without involving the mucosa. Such invasion takes place through the lymphatics of the submucous layer (Fig. 106). Usually the carcinomatous tumors of the rectum are confined to the wall or to the

neighboring lymph-nodes, at least in the early stages of the disease. Occasionally, however, extensive invasion may be seen in the broad ligaments, the bladder, and the retroperitoneal lymph-nodes and areolar tissues, while general metastases are sometimes met with, most frequently involving the liver and lungs. Occasionally, the cells of the tumor penetrate the serous coat of the upper portion of the rectum and form metastatic nodules on the peritoneal surface of the neighboring loops of the in-

FIG. 107.—DIAGRAMMATIC SKETCH TO ILLUSTRATE THE FORMATION OF METASTASES IN CARCINOMA OF THE RECTUM.

The surface of the ulcerated growth can be seen inside the lumen of the rectum at (*c*). At (*b*) is a nodule on the surface of the rectum; at (*a*), a similar nodule. To the left of (*a*) is a small mass which lay in the broad ligament and was adherent to the uterus. There were no other metastases of the growth found.

testine (Fig. 107). These nodules closely resemble tubercles, especially when small or when present in the omentum.

Besides the adenomatous changes already referred to as occurring in connection with carcinomatous new-growths, the mucosa in the neighborhood of a carcinoma may be the site of extensive ulceration or atrophy. The atrophy of the mucous membrane is most frequently seen in connection with tumors causing marked stenosis. The gut above the point of stenosis is very often thin and the mucous membrane greatly altered (Fig. 105).

Epitheliomata occur only secondarily in the rectum, but are the type of malignant tumor regularly found arising from the squamous epithelium of the anal region. The growths follow the regular type of squamous-celled epithelioma seen elsewhere, corresponding in all details with the epitheliomata of the lip. They form nodular, flattened tumors without a pedicle, and may occupy only a portion of the circumference of the anal ring, or may completely surround the orifice. Ulcerative changes are frequently met with.

Microscopically the growths are composed of branching strands of flat epithelial cells, frequently containing a large number of epithelial pearls (Fig. 108). Extensive metastases are not frequent. If present,

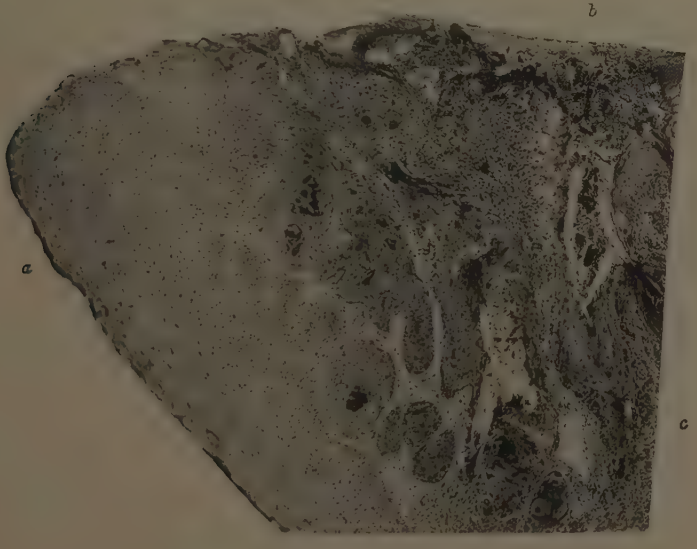


FIG. 108.—EPITHELIOMA OF ANUS.
At *a*, macerated, otherwise normal, epithelial surface; *b*, slough on the surface of tumor mass; *c*, epithelial strands with pearls infiltrating the connective tissue (× about 25 diameters).

they are usually in the superficial inguinal nodes, though the invasion of the perineal tissues may result in involvement of the pelvic nodal groups.

Connective-tissue Tumors.—Sarcomata.—Primary sarcoma is very rarely found in the rectum. Secondary invasion is not infrequent, due to metastases from the original growth in other pelvic organs.

The primary sarcomata are of three types. A form frequently found in the small intestine, but rarely in the rectum, is the lymphosarcoma, which arises in the lymph-follicles of the intestinal wall. Usually, however, such growths are not single and confined to the rectum alone, but are multiple and are present also in some other portion of the intestinal tract. Instead of causing stenosis as do the carcinomata, a lymphosarcomatous growth in the rectum is apt to cause a dilatation of that viscus, or at least not to narrow the lumen. The tumor usually involves the submucosa and

muscularis, and forms elongated masses lying lengthwise to the gut, and is not so apt to produce cylindric thickenings as the carcinoma.

Another form of sarcoma is the spindle-celled or mixed-cell sarcoma arising from the connective tissue of the submucous layer. These tumors may project into the lumen and form pedunculated masses, but usually remain as more or less spheric or longitudinal new-growths.

The most frequent type of sarcoma found in the rectum is the melanoma, a tumor largely composed of pigmented connective-tissue cells. These tumors, however, are extremely rare in comparison to the frequency of carcinoma in this situation. The growths are composed of spindle or polyhedral cells, some bearing pigment, others not. They arise in the submucous tissues and spread not only by the lymphatics but through the blood-vessels, so that multiple melanotic deposits are usually found scattered throughout the organs of the body. Such tumors are extremely malignant, producing fatal results rather more rapidly than the two forms above described.

Endotheliomata have been described (Schlesinger), the cells of the growth being derived from the endothelium of the dilated vessels present in hemorrhoids. Too small a number of cases have been seen, however, to permit of a thorough investigation of the structure and clinical course of these new-growths.

Treatment of Rectal Tumors.—During the memory of surgeons still living the treatment of tumors and cancer of the rectum and anus has been put upon a plane with the surgery of other parts of the body. As a consequence malignant tumors have been lifted out of the hopeless class into which they had been consigned.

Operative work has advanced along rational lines, parallel with the lines of abdominal surgery. The public now understands the frequent necessity of the formerly abhorred and condemned inguinal artificial anus. An artificial anus so placed is now entirely manageable and the sufferer from even advanced stages of malignant growth has much the same hope of respite or cure that he has in cases of the same disease elsewhere.

It must first be recognized that carcinoma is, in the beginning, an absolutely local disease. With the recognition of this fact and with the growing tendency of educated medical men to make digital examinations of the rectum in every case of complaint, there now comes to the surgeon a large number of patients seeking surgical relief early. The prevalent custom of using rubber finger-cots or rubber gloves in making rectal examinations, thus preventing contamination of the finger and diminishing the obnoxious character of the procedure, leads to many more digital examinations being made.

The symptoms of cancer of the rectum are so often vague and fail to force themselves upon the notice of the patient that there will always be some sufferers who apply too late to take advantage of radical operation. Hence **palliative relief** must be considered.

Irritation being granted as a fruitful cause of origin of the disease, it is both logical and practical to endeavor to help the symptoms by

finding and removing irritation. To lessen irritation also retards the rapid progress of the growth. The one irritation ever present is, of course, the passage of fecal material over the ulcerated surface. If this is scybalous, or contains a preponderance of rough food products, husks of cereals or meat remnants, it will be more apt to provoke the surface and induce bleeding. Therefore modified diet, the daily use of soothing laxatives, and frequent oil enemata will so far cleanse the rectum that relief will be obtained from any distressing symptoms of neuralgia and from numerous dysenteric and bloody movements.

The one great palliation of the disease in inoperable cases, however, lies in the early establishment of a manageable artificial inguinal anus. The relief to the system is comparable to that following a gastroenterostomy in malignant disease of the pyloric end of the stomach. There is one additional favoring circumstance, that is, the rectum is the seat of untold numbers of bacteria of serious pathologic types, while the stomach is relatively free.

These detrimental and noxious bacteria are promptly removed from active life in large measure, as soon as the waste food-products are diverted from the rectum, and stagnation at the site of cancer obviated. The physiologic call of hyperemia in intestinal action is reduced to a minimum, and one sees a quick change in the secretions of the ulcer and the whole rectal mucous membrane; whereas before the inguinal anus diverted the fecal current there existed not only a profuse rectal mucus secretion, but a putrid bloody and purulent flow from the disease, which was either washed away by the patient, or left to annoy and be absorbed, After colostomy one sees both discharges cease almost entirely. This agrees with the physiologic law that when an organ is put out of function it atrophies and ceases to secrete, or if secretion goes on, the balance between absorption and secretion is established and no waste products result. Hence the logical utility of the inguinal anus in retarding disease and promoting the health and comfort of the patient.

Delay in creating this beneficent outlet should not be prolonged from motives of sentiment. The tendency of malignant growths to create a dilatation or pouching above them by obstruction extends soon to the sigmoid and colon, so that fecal impaction with fecal toxemia is the inevitable result in great numbers of cases. When this occurs the operation risk, even of creating an inguinal anus, is much increased. The kidneys are choked with toxic products, are taxed to clear the system of impurities absorbed by the colon, and because of toxemia, albuminuria, and indicanuria, the patient may easily succumb.

The picture of a rectum holding back the decaying elements of ulcerating cancer, plus the excrementitious contents of the colon in the pelvic sink, is not one easily exaggerated. The absorption of such foul toxins is the immediate cause of the greenish cachexia, secondary anemia, and weak vitality characteristic of these patients, and the surgeon often sees a prompt restoration to natural color of the complexion when an artificial outlet is made in the groin. The operation greatly improves the health and gives notable comfort for many months.

When colostomy has been performed codein or opium should be given. Their value in checking liquid movements, reducing the wear and tear of neuralgia, and retarding tissue change, is added to their well-known power in lulling anxiety caused by suffering, procuring sleep, and inducing a peaceful state of mind which goes far to reconcile the patient to the inevitable.

Operation for Rectal Tumors.—The surgeon has a choice of several methods, which he must comprehend fully in order wisely to apply the right one to the case in hand.

Much will depend on whether the growth is a tuberous or an annular cancerous mass. If tuberous, it may be low down and limited to a small area of the rectal circumference, and may have a sessile base or a neck smaller than the growth. For such a tumor the legitimate operation will be one of excision of the growth and a neighboring part of the ample wall of the rectum. But if it be annular, or spread over a third of the circumference, it will be unwise to trifle with minor procedures.

The two major operations are amputation of the rectum and resection. Amputation consists in removal of the entire rectal tube from above the disease to the anal margin. Resection consists in cutting out that portion which is diseased and uniting uninvolved parts above and below into a continuous channel.

The methods of operating are classified according to the route by which each is done. The rectal, vaginal, perineal, sacral, and abdominal (or combinations of these) comprehend the available routes.

Rectal Method.—If the tumor is very low down, it may perhaps be removed through a well-dilated sphincter ani and be removed better and more safely than by any other method. The rectal method does not differ much from the operation for removal of hemorrhoids. If the growth occupies a small marginal surface and has not invaded the muscle, it may be legitimately excised, if the operator but keep in mind the observation that three-quarters of an inch of apparently uninvolved mucous coat is the least margin of safety. Microscopic study shows that invasion of the submucous, the muscular, and the extra-muscular layer is progressively wider as one leaves the mucous surface.

If the growth is not movable at the submucous coat, it may be known to have invaded the muscular, and then one cannot rightly leave the sphincter or any of the intestinal tube.

If there is wide involvement of the mucosa alone, that is, if the growth is superficial and glandular, a resection of the mucous tube after the method of Whitehead's operation for hemorrhoids may be sufficient. The number of cases in which this limited operation is available is not large, and should be more and more restricted. Its advantage is great, because of the subsequent sphincter control.

The one bugbear of rectal surgery is incontinence of feces. No operations involving removal of the sphincter can insure subsequent control. Nevertheless the operator must have but one guiding thought in his operation, namely, removal of *all* the disease, and the patient is obliged to take the consequences. Substitutes for a sphincter will be spoken of later.

The vaginal method holds a legitimate place in the procedures of choice. The rectovaginal septum is so close to a large number of rectal growths that they can be felt by vaginal touch; hence this tube has been adopted by some surgeons as a feasible avenue of approach.

The usual preliminaries being carried out, and a lithotomy position maintained, the operator incises through the posterior vaginal wall, and carries his incision around the anus into both the ischiorectal fossæ, or he splits the perineum in the median line, dividing the vaginal and rectal sphincter precisely as if a complete rupture had taken place in parturition. Even more, he may split the rectal sphincter in two halves, carrying his incision back to the coccyx. This implies careful restoration afterward of the divided muscle ends. The rectum can now be readily isolated by blunt dissection from the wide open pelvis. There will be considerable hemorrhage during this stage, which can be checked by clamps and packing.

The peritoneal cavity will be opened by cutting across the vagina behind the cervix uteri, and the scissors will cut the peritoneum as it is reflected from the rectum, so that the latter can be drawn down several inches, held only by its sacral cellular and vascular connections, which stretch enough to permit resection of three or four inches. The intestines must be kept in the abdomen by gauze in the form of pads ten inches square, or by narrow pads (4 inches by 10 inches) with tapes attached.

If the disease requires resection of several inches, a series of sutures can be placed so as to unite the healthy anal end to the upper sigmoid end. These must be in a double row, the first one on the sacral aspect holding the muscular layer, the second the mucous layer.

The repair of the muscular and mucous coats of the rectum having been accomplished, the vaginal wall is sutured independently by catgut continuously applied, and the sphincter and perineum are repaired as in perineorrhaphy, namely, by silkworm-gut stitches through the skin securing the divided muscular ends in apposition. Some advise a separate catgut stitch to hold the muscle end with some precision, but it will be wise to use here only fine catgut for exact apposition, and rely on the silkworm-gut to secure permanence. The silkworm-gut should remain in place for ten days.

Even with these precautions there is apt to be a small temporary fecal fistula through the vaginal suture line; but as the mucosa in both the rectum and vagina has been inverted into its respective canal, this small fistula heals spontaneously by granulation.

This rather elaborate procedure is by no means as easy as its description suggests. I have, however, proved its utility, with less shock and great simplification in badly involved cases, by first having established an artificial anus; the sigmoid end of the colon being closed and dropped back into the abdomen. Then, disregarding the fecal discharge, now arrested at the inguinal opening, the disease is eradicated with such liberal removal of the involved rectum and vaginal wall as is required, the wound packed, and allowed to heal by granulation.

It is amazing how well the pelvic outlet closes as it heals, and the open

lower end of the sigmoid becomes continuous with the vagina, above the level of the uterus. Nevertheless, with absence of normal fecal irritation the mucous secretion is pure and finally ceases, as the balance between secretion and absorption is established; so that the patient notices no more than would be normal to the vagina alone. This method seems to be more in accord with modern surgical principles than an attempt to suture and to re-establish a normal anal discharge; inasmuch as the surgeon always has before him the difficulty of reuniting the ends, and is tempted to excise too near the disease in spite of his best intentions, thus inviting recurrence.

By the vaginal route it is possible to remove a limited part of the anterior wall of the rectum, if the growth is fortunately discovered early, and happens to be placed in this situation. Such occasions, however, are rare.

The **perineal route** was the earliest adopted by surgeons for extirpation of rectal cancer, and for many years was the accepted method. First offered by Lisfranc, in 1822, it was subjected to many variations, and in spite of drawbacks is utilized by some today. Its great drawback is the incontinence resulting from removal of the sphincter with the anal portion of the rectum, and the establishment of a trumpet-shaped opening.

Operation.—Assuming the disease to be so placed as to require removal of the lower part of the rectum and anus, the patient is placed in the lithotomy posture, and a free incision is made in the raphe of the perineum, thence around both sides of the anus, meeting in the median line, and extended to the coccyx or beyond. The coccyx may be excised if necessary, to gain increased space. The anus had best be closed by a heavy purse-string suture, to contain its contents, and enable one to handle it freely.

Having drawn down the closed anal portion with sphincter attached, the operator finds on traction that it is held back by the tubular investment of the levator ani and pelvic fascia, and by snug anterior attachment to the base of the bladder and urethra in the male.

By a circular sweep of the knife at the sides, and between the coccyx and anus, this fibro-muscular support is cut, and a finger can readily be used to separate the rectal tube, except in front, where care is needed. In the male urethra a sound should be placed to separate the growth without tearing the bladder. It soon yields to traction and blunt dissection, with not much hemorrhage, and when loosened from the sacral hollow it is found to be held only by the peritoneum where it stretches in front to the bladder, and behind by the sacral mesorectum. Almost all the nutrient vessels are contained here. If the diseased area is high, the peritoneum must be opened and cut around the sides of the drawn-out rectum, which gives great freedom; so that the proximal end can be brought to reach the anal skin. This is all that is required, and the operator now amputates, after tacking the wall of the bowel to the skin to prevent retraction. The parts are now washed and a tube of rubber, wound with iodoform gauze, inserted into the bowel, with an additional sacral drain at the tip of the coccyx.

The Coccygeal and Sacral Methods.—For twenty years the experience of world-famed operators has advanced the operative method of removing rectal cancer along lines of more thorough extirpation. Acknowledged prominence has been given to the method and to the determination of Kraske, of Freiburg, to remove to their fullest limit behind the rectum all barriers that prevent elaboration and safeguarding of the excision. The demonstration that the presence of the lower half of the sacrum and the coccyx was not necessary to the integrity of the pelvis led Kraske to propose their removal up to the limit of the third sacral foramen. From this emerges the sacral root giving nerve-supply to the rectum and bladder. The destruction of one third root leads to impaired function, and of both to paralysis of the bladder. The nerves emerging from the fourth and fifth foramina are unimportant. Until the past five years the Kraske method has been quite generally accepted as superior to all others in permitting removal of cancer in the sacral hollow or in the upper rectal region. Kocher alone has maintained that removal of the coccyx only, gives enough room for thorough work.

A description of *Kraske's operation* will exhibit the principle of all sacral methods of resection of the rectum. The patient is placed on his right side with hips raised on a sand-bag and thighs well flexed on the abdomen. A deep skin incision is made in the median line, from the anus to the sacrum, and along its upper border to near the posterior inferior iliac spine; this is carried down to and divides the sacrosciatic ligaments and some parts of the gluteus maximus muscle; these being separated from the sacrum, a chisel or saw is applied across the sacrum below the level of the third posterior foramen. Some prefer to pass a Gigli saw underneath and cut the sacrum on this line; others divide it by heavy bone-cutting forceps. Rehn and Rydygier make an additional transverse skin incision and save the bone attached as an osteoplastic flap, hinged on the right side. Modifications of this extreme bone removal suffice in many cases according to the extent of the involvement, and have been advocated by Heinecke, Bardenheuer, Hochenegg and others; each removing part or all of the coccyx and the left side of the sacrum only, or some part within the limit set by Kraske. All have for many years been such ardent advocates of the method that we have evidence of its great merit.

In subsequent steps, however, we have evidence of its deficiency. The exposure of the soft parts being accomplished, approach to the rectum is obtained by cutting in the median line through the junction of the levator ani, dividing them laterally above the sphincter. The rectal tube is now roughly dissected from its various attachments, most intimate at the anterior aspect. The peritoneum must usually be opened and split around the rectum to permit its descent. As far as need be, the suspending mesorectum must be drawn upon and ligated, so as to leave the superior hemorrhoidal artery absolutely the last part to be tied. By this procedure a free portion of the rectum can be drawn down and united to the anal section,—if happily it be uninvaded,—thus com-

pleting the tube. Should the union be impossible, the drawn down end must be stitched in the sacral wound and left as a permanent anus.

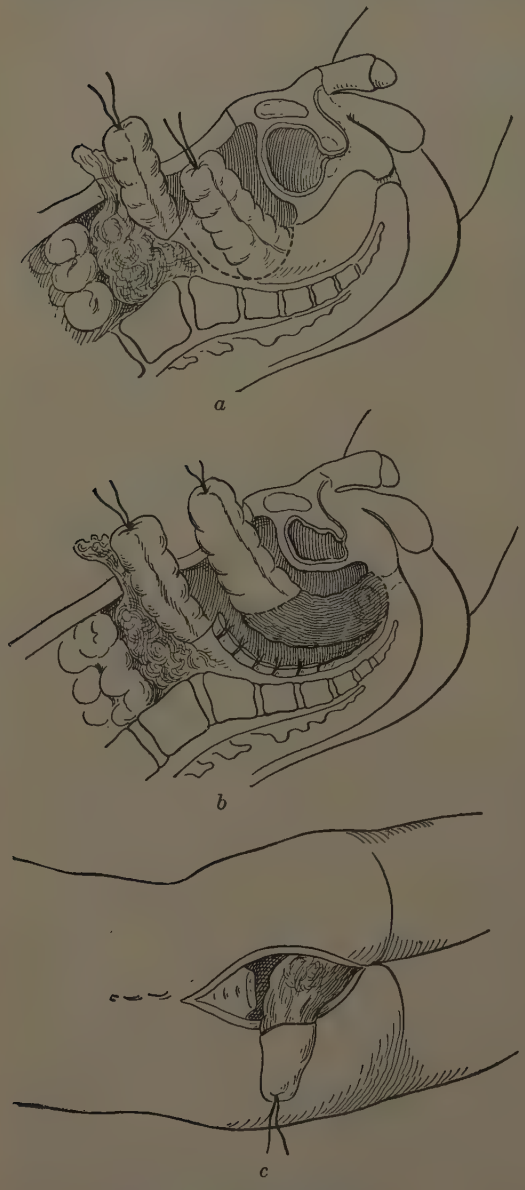


FIG. 109.—ABDOMINAL ROUTE FOR CANCER OF THE RECTUM. TRENDELENBURG POSITION.

a, Divided ends of the sigmoid inverted by purse-string suture. Dotted line shows section of the pelvic peritoneum. *b*, Second step. Rectum dissected from the pelvis after ligation of the mesorectum. *c*, Third step. Rectum ready for removal. Kraske method not usually necessary, as the amputation above the anal portion can be done from above. This affords excellent drainage.

Gersuny has devised a method of partially obstructing and transforming this deficient anus, by twisting the bowel one half-turn or more before stitching, to make a spiral end to the outlet in hopes of its being more manageable. This addition has been generally abandoned as giving an improvement in but a small number of cases, and adding a risk of infection and of gangrene of the end.

The ideal to be attained is restoration of the canal without tension, and with a continued sphincteric anus. Two reasons often prevent this: First, the liability to non-union of the gut from the absence of peritoneal investment; and, second, the tension which leads to gangrene, or at least tearing of the stitches through the friable tissue.

A long-enduring fecal fistula often results therefore, which, however, generally closes in time and leaves a continent rectum.

The conviction has gradually forced itself upon the surgical world that the sacral method, while usually more thorough than any other, for mid-rectal or high cancer, is inadequate to permit extirpation of the lymph-

nodes in the sacral hollow, with satisfaction. Hence surgeons by necessity have lately turned to the **abdominal route** as giving access to the rectum and the sacral lymph-nodes, and, as if by general consent, the deficiency of the sacral and lower routes has caused a wide acceptance of the abdominal or the combined method as preferable for cancer of the middle or upper rectum.

Kraske himself has become its most ardent advocate. The alluring exhibition of the basin of the pelvis from above, when the patient, man or woman, has been placed in the Trendelenburg position, with all the intestines kept in the upper abdomen by pads, and with only the sigmoid and rectum in view, has invited every surgeon to study rectal tumors from this aspect. He sees at once the upper aspect of the growth, its peritoneal and lymphatic invasion. He sees that by ligation of the superior mesenteric artery in the mesorectum the hemorrhage is controlled largely before any step is taken for removal; that anastomosis is easy if the tumor is near the sigmoid; that if it be lower, the rectum can be most easily loosened from the pelvis and dissected even down to the anal portion.

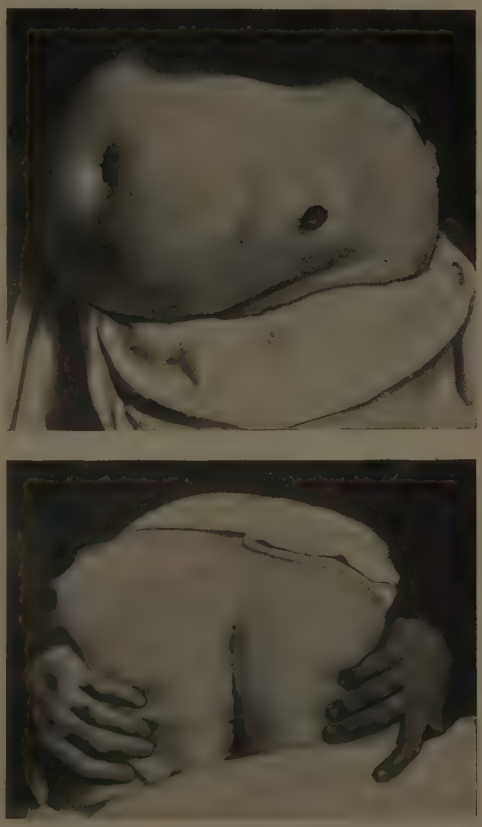


FIG. 110.—PERFECTLY MANAGEABLE LEFT INGUINAL ANUS FOUR YEARS AFTER COMPLETE REMOVAL OF A CANCEROUS RECTUM.

It is consistent with modern thoroughness that this should be the accepted route for high or middle rectal surgery. Although suggested by others, Quénu was the first ardent advocate of this method; now advanced by Kraske and indorsed by his continental colleagues. In America, Keen, Weir, and others have for ten years occasionally practised it with growing enthusiasm.

Kraske advocates the abdominal separation of the rectum after division just above the growth, down to its lowest attachment. Then transferring the patient from Trendelenburg's to the right lateral prone posture, he makes a quick sacral operation, and completes it as well as

circumstances will allow; anastomosing or creating a sacral anus if necessary (Fig. 109).

American surgeons, led by Keen and Weir, are more prone to create an inguinal anus at or before operation to eliminate the rectum, avoiding transit of feces through the pelvis, with its many mishaps, anal inefficiency, and provocation to return of the disease.

At best, the victims of rectal cancer must be satisfied with a long extension of life, a reduced operative mortality, and the relatively slight discomfort of an inguinal anus (Fig. 110).

Kraske quotes his ten recent cases of the combined method, all done for most advanced diseases, as yielding four deaths, all in men, but anticipates far better results as it is more widely adopted for all cases. The gravity of operation for pelvic cancer is generally increased in men, whether from the greater tolerance of women to pelvic surgery, or greater facility in removing the less adherent rectum, cannot be said.

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CHAPTER LV.

EXAMINATION OF THE URINE IN RELATION TO SURGICAL MEASURES.

By David L. Edsall, M.D.,

PHILADELPHIA.

In recent years a somewhat violent discussion has been going on among those who would often make the clinical laboratory the court of final appeal and those who would divest many laboratory methods now used of much or all of the clinical value that has been attributed to them. Both worshipers and iconoclasts have been particularly busy with certain methods of examining the urine; indeed, in no connection has this discussion been more lively than in relation to methods that are intended to furnish knowledge of value in determining the condition of one or both kidneys. It is my province in this article simply to express briefly my views regarding the value or lack of value of some of the methods of examining the urine, particularly some of the more recent ones, confining myself exclusively to a few questions that are of especial surgical interest. It will be necessary, in order properly to economize space, merely to state my views, without attempting to justify them by extended technical discussion, and without giving descriptions of methods. The latter can much more suitably be sought in books that deal with such matters at length.[1]

Since I cannot entirely share the enthusiasm of some writers regarding the matters that fall within the sphere of this article, but approach their discussion with the feeling that modern methods of examining the urine have in but few ways furnished really satisfactory additions to our diagnostic powers, my task is not altogether attractive; for it amounts largely to a criticism that is more or less unfavorable or skeptical. Many of the questions to be discussed remain at present in so chaotic a state that it is hard, at best, to pass fair judgment upon them. The difficulty in learning the actual value of most of these methods from the statistics which have been accumulated has been largely increased by the fact that a considerable proportion of those who have greatly overpraised them, as well as many who have most severely condemned them, have carried on their discussions from the point of view of expecting clinical-laboratory methods to furnish specific facts of conclusive value in diagnosis and prognosis. This is, of course, entirely out of the question. The point at issue is the capacity of these methods to furnish fragments of knowledge that, when added to numerous other fragments gained by bedside work, will aid materially in forming a correct opinion of the case.

Another misconception as to the value of these methods is based upon a lack of understanding as to what many of them are actually intended to accomplish. Many persons appear to feel, for example, that cryoscopy has or should have some mysterious power of determining things that are beyond and above the powers of other methods directed toward the same end; while, as a matter of fact, cryoscopy simply does much the same thing as do some other methods. When carried out properly, however, it is more delicate and gives, in a certain sense, a more comprehensive result—although not necessarily one that is more valuable clinically.

It is impossible to reach a fair decision as to the value of any of these methods, unless one admits at the outset that, as a rule, no one of them can furnish knowledge that of itself suffices for a diagnosis. It is likewise important that any one attempting to use them in reaching a conclusion should not only be familiar with the fact that a method is intended to furnish, for example, knowledge of the state of the kidneys or the pancreas, and should have some acquaintance with the statistical results of its use, whether favorable or not; he should also be familiar with the manner in which the method is supposed to accomplish its end, and should have some conception of its inherent powers and limitations. A clinician may be unskilled in the use of a method, and yet get useful results through an assistant; but he cannot do this safely unless he understands the rationale of the method sufficiently to be able to determine largely by himself the value of the result in an individual case, and to depend upon the laboratory man almost solely for an accurate result rather than for an opinion as to its value.

Again, there has recently been a strong tendency to seek the delicate and difficult methods of the physicist and of the physico-chemist in clinical work, in order to insure greater accuracy. While accuracy is in itself always desirable, it should be remembered that—contrary to the conditions in physical work, for example—there are always in clinical questions a large number of uncontrollable variable factors; and the most accurate method available can usually determine only one of these factors. The very delicate and accurate methods are usually extremely time-consuming; and unless absolute accuracy is essential and yields important results, other easier methods that are approximately accurate may give just as valuable results, without so much waste of time. If the more delicate methods are used, skill and experience are essential, if serious technical errors and consequent gross clinical errors are to be avoided; and unless one has such skill and experience, one had better depend upon simpler methods.

Let me first consider briefly the most serious of the questions that I shall refer to, the determination of the **functional capacity of the kidneys.** The question of the separate capacity of the individual kidneys can be studied only by securing separately the urine from each side, and this will be considered later.

The power of the two kidneys, working together, to carry on their function properly and to stand some extra strain is quite as much a medi-

cal consideration as a surgical; but it becomes a matter of especially critical anxiety to the surgeon when serious operations are projected. In this we are not at present to any noteworthy extent better off than we were before the more recent methods had been devised. We have known for many years that, while one may ordinarily draw reasonably accurate conclusions from a study of albumin, casts, and other formed elements, and from general clinical observations of the patient, the results not infrequently lead one into error. A quantitative determination of various solid constituents of the urine has been widely used, in order to make diagnosis more accurate; but the results are little, if at all, more satisfactory. As to albumin and casts, it is perfectly well known that these may be nearly or quite absent, when serious disease of the kidneys is present; and, on the other hand, that they may be present, and yet there may be no serious essential disease of the kidneys, the secondary effects of disease situated elsewhere having produced them. They may also be due to disease of one kidney, while the other is entirely capable of carrying on all the work. Furthermore, albumin and casts may be present to a more or less considerable amount, as the result of actual renal disease; and yet the kidneys may be capable of going through serious extra strain; and the amount may be no indication of the seriousness of the renal disorder. Very commonly, in surgical cases which are associated with a toxemia (especially, that is, in cases in which there is absorption, or general infection, from local infection of some sort), a little albumin and a few casts, or more marked conditions, up to the signs of decided nephritis, may be found in the urine, and may disappear when surgical intervention has caused recovery from the primary trouble. In such instances the condition of the kidneys is evidently due to irritation or actual nephritis, as the case may be, secondary to the other disease; and the existence of such urinary abnormalities then constitutes an actual indication for operation, provided the circumstances are not such as to make this highly dangerous. At times, however, such signs are due to grave renal disease, which may or may not be secondary to the primary surgical affection. In such a case, any serious operation—particularly if it involves the urinary tract—may produce dangerous renal failure and be more hazardous than letting the patient alone. Unfortunately, this same danger may be present, even when the urine seems to ordinary tests normal or nearly so.

The only rational way of attempting to determine whether, in these various circumstances, the kidneys are in a dangerous state or not has been to search for the cardiovascular and other general evidence of serious chronic renal disease, and to use well-balanced judgment in interpreting the urinary and other more general findings. As a rule, when a surgical cause for renal irritation is present and other causes are absent, it is easy to determine that operation is indicated unless the circumstances in regard to the kidneys are pretty desperate; but when both a surgical cause and other possible causes are present, the matter is far less simple, and fine judgment is required in individual cases.

Among the other methods of examining the urine that have been

used in attempting to make this matter clear, I may mention the estimation of the amount of urea excreted, the amount of chlorids, and the amounts of total solids. The results from these methods are little, if at all, more satisfactory than those from the common routine practices; and this is not surprising. As to **urea,** in the first place, the commonly used method for estimating this substance,—the hypobromite method in its various modifications,—has an unavoidable error connected with its use that is so large as to make the method not far from practically valueless. It is unquestionably valueless, unless carried out with the best apparatus and with great care as to details; and these conditions are very rarely met. More reliable methods require too much time and skill to be suited to ordinary clinical work. Granting that a more reliable method be used, the estimation of urea, chlorids, or total solids is absolutely valueless, unless the amount of intake in the food in the twenty-four hours is determined, and unless the total amount excreted in this time of the special substances being studied is accurately determined. Percentages are worthless, as they vary enormously at different times in the same person, according to the time of day, and especially in relation to the amount of food and of fluid taken shortly before. To know the intake is essential,—for an apparently poor excretion may be due, not to retention, but to a low intake,—since, even in normal persons, the excretion, of course, varies directly with the intake.

The most practicable means of accomplishing a comparison between the intake and the outgo would seem to be a study of the nitrogen of the food and urine; for, with a simple diet, the amount of nitrogen in the food may be determined accurately, and may even be estimated fairly accurately from tables prepared from large numbers of analyses. Moreover, the estimation of the urinary nitrogen, while time-consuming, is not difficult. Even when the total nitrogen intake is accurately determined, however, and is compared with the nitrogen excretion, the result is, unfortunately, of little diagnostic or prognostic value; for we have learned, chiefly through the work of von Noorden and his pupils, that although actual severe nephritis may be present, retention may be absent unless the condition of the patient is desperate, or, at most, periods of retention may alternate with periods of good excretion. Even though retention were present, it would not necessarily mean that it was due to inability to excrete properly; for retention is frequently purposeful and proper, in that it is intended to accomplish the rebuilding of tissue that has been lost—a process that, of course, goes on usually in persons with any disease, when they are showing temporary or permanent improvement.

We meet, therefore, with so many factors that influence the results that the most difficult quantitative methods of studying special components of the urine furnish little, if any, more evidence of a reliable sort than do the simpler qualitative and microscopic methods. I have mentioned in a little detail some of the factors that disturb conclusions, because I find that they are overlooked with extreme frequency when the value of these methods is being considered; and because, also, they are equally forcible objections to some of the newer methods. It may, per-

haps, be fairly said that there is this value in studying the **chlorids:** they may be determined accurately by a comparatively easy method; and if the intake remains much the same, one can get some idea as to the changes in the excretory power in the same case from time to time and can, therefore, form some conclusion as to the progress that the case is making. Such conclusions are not, however, of great value, and must be recognized as merely approximate.

Within very recent years, attempts have been made to gain more accurate knowledge, chiefly in one of two ways: (1) by using more delicate methods; and (2) by testing the capacity of the kidney (*a*) to excrete abnormal substances that have been swallowed or injected into the tissues or (*b*) to excrete increased amounts of some normal substances. Under (1) come, more especially, cryoscopy and determination of the electric conductivity of the urine. Neither has added to our clinical resources when we are studying the mixed urine from the two kidneys. I may dismiss the question of the electric conductivity of the urine by saying that it determines simply the number of electrolytes (that is, of salts that undergo dissociation) in solution in the urine; that clinical experience with the method has, up to the present, shown nothing that indicates it to be even as useful as cryoscopy; that the abnormalities so far found cannot be definitely interpreted; and, finally, that the urine is so complicated a solution as to be probably quite unsuited to the use of this method. The proper sphere of the latter really appears to be limited to simple, or comparatively simple, solutions.

Cryoscopy,[2] or the determination of the freezing-point of a solution, is an exceedingly accurate method of learning the number of total molecules in the solution. There is no *a priori* reason why cryoscopy should furnish any more useful clinical knowledge than that provided by other good methods for determining similar things, except that cryoscopy is a particularly delicate method; and it determines the total amount of all the dialyzable molecules present, while most of the other methods that can be used determine the amount of only one particular substance, such as nitrogen, urea, or chlorids. While total-solid determinations do tell the entire quantity of solids, the methods for the latter determinations are, in the best of circumstances, likely to be inaccurate; and, as usually carried out, they are very inaccurate. They, furthermore, include any albumin present; while cryoscopy does not; and it is a disadvantage to include the albumin in the same estimation, when one wishes to know the capacity of the kidneys to excrete the substances that should pass through them.

The advantages of cryoscopy that I have mentioned are, however, of minor importance when compared with the very important disadvantages that cryoscopy shares with previously mentioned methods. The most serious disadvantage is that the results from cryoscopy are, of course, influenced by the diet quite as much as are the results from other methods; and it is apparent that there is absolutely no way of determining, except by the most impossibly elaborate means, exactly what the molecular concentration of the urine should be in any particular

case on any particular diet. The nearest that we can come to this is to determine in a very large number of normal persons what the average result of cryoscopy is when a very carefully regulated diet is being used; but the variations in individuals are such that a comparison of the result in any one case with an average normal would amount to absolutely nothing, unless the difference should be very decided. If it is very decided, less accurate and less difficult methods would tell quite as much. I have never been able to see that cryoscopy of the urine, except as an accurate means of comparing the urines collected separately from the two kidneys,—and this question is not now under discussion,—can offer any valuable clinical information; chiefly because of the reason mentioned. If extensive studies had shown that it does give such information, this result would, of course, have to be accepted, even though unexpected; but studies have not shown useful results, nor have the various combinations, such as cryoscopy and chlorid-determinations, demonstrated anything of importance. In studying purely physiologic or pathologic questions these methods have been very valuable, but that is another matter.

The question of cryoscopy of the blood is not strictly within my province, but I may be permitted to mention that, with some modifications, the objections that I have noted to cryoscopy of the urine apply to cryoscopy of the blood; and that the results of its use have not been satisfactory, except in the hands of its enthusiastic advocates.

Testing the **excretion of abnormal substances** has, at first thought, more in its favor, in that it avoids the complexities of learning the intake of food and comparing this with the outgo; and that it likewise avoids some other variable physiologic and pathologic factors. It simply puts a demand upon the kidneys and lets one observe how well they respond to this demand. Various substances, such as potassium iodid, salicylic acid, etc., have been used in past years for this purpose; but at present this method is of interest chiefly in relation with methylene-blue and phlorizin. When methylene-blue is injected, it rapidly begins to appear in the urine; and within a given period it is entirely excreted in normal cases, either in the form of the dye itself, or as its colorless chromogen. The time of its appearance, the duration of its excretion, and the total amount that can be recovered have been used as criteria of the functionating power of the kidneys. There is no doubt that the excretion is likely to be delayed in cases with bad kidneys, and also to be either shortened in duration or, at times, abnormally prolonged, but normally rapid excretion may occur also in nephritis, and sometimes, indeed, the excretion is abnormally rapid. I do not think that it is profitable to say more here in regard to this method than that the results have been altogether too uncertain to permit of any reliance upon them. Methylene-blue is, however, useful—as is indigo carmin—as a means of determining through cystoscopic observation the simple fact that the urine is coming from both ureters or from only one; and in order to determine, also, that fistulous tracts communicate with the urinary passages.

Phlorizin has been used on account of the fact that after its injection the kidneys normally excrete glucose. This glycosuria has recently come

to be generally considered as the result of some alteration in the renal epithelium that permits of the passage of glucose, which normally is retained. It appears to me to be still quite as probable that the glycosuria is due to breaking up or altering combinations in which the glucose normally exists in the blood, the sugar thus coming to be wholly or relatively in free solution, and thus passing the normal kidney easily. However this may be, glycosuria does ordinarily appear promptly when the kidneys are normal; and it usually appears later, and sometimes not at all, when the kidneys are diseased.

This test seems to deserve more serious consideration than those that have been mentioned. There are undoubtedly errors associated with it. In cases of acute nephritis, for example, the excretion is often hastened, instead of being delayed. Error from this source can frequently be avoided to the extent that one simply lays no stress upon quick excretion when the usual signs of acute nephritis (much albumin, many casts, and blood) are present; but this alone would exclude some very important cases from the use of this test. On the other hand, even the enthusiastic reports of devotees of its use—of Kapsammer,[3] for instance—show that at most it indicates simply the ability of the kidneys to excrete glucose; that, though it be positive, grave disease may be present; and that the excretion is sometimes delayed, when all evidence of serious disease persistently remains absent, although great strain, such as that of a severe operation, is thrown upon the kidneys. It is, therefore, by no means an absolute test; but the results up to the present appear to make it sufficiently accurate to render it desirable for one to be cautious, in any case in which the excretion of sugar is delayed or is slight; while, on the other hand, if the excretion is prompt and of good quantity, and if there are no signs of acute nephritis, the kidneys are likely to be healthy. I feel, however, that while the test has some value, it should be used only when a conclusion cannot be reached in other ways; for it is not unreasonable to think that the abnormalities set up by it in the kidney may, at times, be harmful, and there are on record a number of instances in which damage was thought to have been caused by the use of the test. These latter cases are not wholly convincing, but they are enough to suggest caution.

Tests of the **response of the kidneys to increased amounts of normal substances** have been carried out chiefly with ordinary salt and water. The ingestion of large added amounts of sodium chlorid within a short period is usually followed by a corresponding, or even an excessive, increase in excretion, provided the kidneys have good excretory capacity; and the excretion is commonly imperfect, or even actually reduced below its previous point, if the functionating capacity is poor. The results of this test, however, in the hands of Steyrer and others who have investigated it extensively, have been irregular and uncertain; and, furthermore, I am convinced from my own studies that the test may have dangerous results in cases that are already damaged, and I think that it should be discarded.

The power of the kidneys to excrete suddenly increased amounts of

water, which has been investigated by Illyes and Kövesi, Strauss, Albarran,[4] and others, seems to be deserving of more extensive trial. Certainly normal kidneys react, as a rule, much better than those that are diseased. The results are variable and at times difficult, as yet, to interpret; and a decision as to the value of the test cannot at present be reached. While not yet, to my mind, of any definite clinical value, it is particularly worthy of study, because of the nature of the test. That is, it purports to determine, not merely what the kidneys are doing at any particular time, but what they are capable of doing in response to an extra demand of a normal character.

So far, then, as our power of determining the functionating capacity of the two kidneys is concerned, I think that we must still rely upon an examination of the urine by means of the older and simpler methods, *i. e.:* examination for albumin, casts, and other formed elements; total quantity in twenty-four hours; and specific gravity. Even more than this, we must rely upon a searching history and general examination of the patient, in order to discover or eliminate the distant effects of renal disease. The results, of course, are not always reliable. They can, perhaps, in questionable cases, be made more accurate by using the phlorizin test, in that prompt excretion of sugar, provided acute nephritis is absent, supports other evidence of apparent good function; and delayed or slight glycosuria increases the significance of other abnormalities that may have been discovered by ordinary examination of the urine or by general examination of the patient. When the phlorizin test alone is indicative of disease and other investigations are negative, caution is demanded; but this test alone cannot be relied upon to settle the matter finally. It appears to be fairly clear that if the results from the phlorizin test are to be relied upon, the dose should be from 0.01 to 0.02 gram, rather than 0.005 gram, as recommended in the earlier days of its use.

When we come to the question of **determining the separate capacity of the two kidneys,** we have one great advantage over a study of the mixed urine. In the latter we must contrast our results with our conception of the normal; usually, that is, with an average obtained from various normal persons. With the separate urines we can at once contrast the two urines from the same individual, and usually tell which is relatively the more nearly normal. When, however, it is desired to determine whether one or both are actually normal or, at any rate, capable of carrying on the whole renal function, we have very limited powers. We can merely say that one is doing better work than its fellow; and, beyond this, must limit ourselves to the statement that one kidney appears to be behaving in the manner that a normal or an abnormal kidney, as the case may be, usually behaves. That is, we have no absolute criteria on which to base our conclusions, and can merely contrast the results with those obtained in cases known to be normal. We must recognize that the tests we use for determining this are the same as those already discussed in connection with the mixed urine; and that when it comes to establishing, not the relation of one kidney to the other, but its relation to the normal, the tests have the same errors that they have when used with the mixed urine.

It is, however, possible in a large proportion of cases, as I have stated, to tell by means of a combination of tests how much work one kidney is doing as compared with the other. This is a very decided step in advance of a simple examination of the urine from each kidney for albumin, casts, pus, bacteria, etc. The latter examinations may show abnormalities, and in such instances the result is important; but they may be negative when the kidney is seriously diseased. At best, they merely show that abnormalities are present; while they indicate little or nothing regarding the work that either kidney is doing or is capable of doing. Unfortunately, the best of the other tests does not provide an absolutely reliable contrast between the two kidneys. The more seriously diseased kidney may secrete more fluid; it may even, in some instances, secrete more solids during the time of an examination; and it may, if acutely inflamed, respond more quickly to the phlorizin test. Further, a kidney may respond more favorably to the test as compared with its badly disordered fellow, and yet it may be itself gravely diseased. A good illustration of this is afforded by a case reported by Kapsammer, in which a kidney that was a mere pyonephrotic shell responded well to the phlorizin test, and was evidently doing most of the work; while its fellow, not previously known to be diseased, responded very poorly to phlorizin, and evidently did but little of the total excretion. The latter kidney proved, when examined pathologically later, to be the seat of a severe interstitial nephritis. Kapsammer uses this result as evidence of the value of the test in discovering the incapacity of an apparently sound kidney, in this instance the one that was the seat of nephritis. It appears to me, however, to be equally good evidence that the test may lead one to consider as sound a kidney that is so gravely diseased that little of its structure is left; provided only that it has still some relatively healthy epithelium, capable of excreting glucose, as was the case with the pyonephrotic kidney.

There are, therefore, very evident possibilities of error that cannot be avoided; but all tests of any function, whether they be clinical or laboratory tests, have such possibilities associated with them. I think that the evidence indicates that by using the tests that I have mentioned the possibility of error is reduced if, together with these tests, the general features of the case are carefully studied. The contrary views of Rovsing,[5] Israel,[6] and others, who consider the tests confusing rather than helpful, are based upon their consideration of uncertain statistics, and are not convincing. The results of those that have had extensive experience with these tests—Casper, Albarran, Kapsammer, and others—indicate that they have value in reducing error.

It does appear, however, that Rovsing and Israel have some right on their side in contending that an absolute danger-line should not be drawn on the basis of these tests, operation being refused if this line is passed. We have, as has been stated, no accurate way of telling when any kidney is normal; or, if abnormal, how far it departs from the normal. A danger-line, no matter where drawn, is therefore purely arbitrary; and we are not yet in a position to tell by means of these tests

when the actual danger is great. If an arbitrary danger-line is drawn and decisions are based upon approach to it, the number of operative deaths will undoubtedly decrease in proportion as this line is drawn well away from certain danger; but the number of non-operative deaths will increase in the same degree. It is always a question of balancing apparent hazards against the urgency of the indications for operation; not of establishing a routine practice.

Of the tests to be carried out, I think that, following what is essentially the method of Casper and Richter,[7] this is the best and most practical: *i. e.*, determine the total amount within a given time, the time being made as long as possible; determine its concentration by cryoscopy, if skilled in this method; and use the phlorizin test. Unless one is skilled in cryoscopy, I think one had better, instead of it, determine the specific gravity carefully. As was said of the study of the mixed urine, the dilution test will not improbably prove of some decided use; but it is, as yet, not very practical, and its value is not well determined. Elaborate combinations of tests, such as those used by Albarran, cannot be carried out unless the surgeon has available an unlimited amount of the time of a skilful laboratory man. Even then, I question the advisability of using so large a number of tests. The complexities in intrepreting the results, which, with the various methods, are often more or less conflicting, are frequently so great that they interfere with, rather than increase, the accuracy of one's conclusions.

In regard to the examination of the urine for other purposes, I can, in most particulars, say very little without repeating what may be found in any book dealing with such matters. There are, however, some points that I feel impelled to insist upon. The **total quantity of the urine in twenty-four hours** is not noted as commonly as it should be; and when it is noted, the result is very often misinterpreted. In a case in which there is severe acute nephritis or a severe exacerbation of chronic renal disease, or in which there is dropsy from any cause, a low amount of urine usually indicates poor excretion and retention of fluid; but when such circumstances are not present, it usually indicates only that a small amount of fluid is being taken, or that fluid is being lost through sweating or by other channels. The latter point, especially, is not appreciated sufficiently often; and disquiet is frequently produced by an oliguria that would be at once explained, if one should consider properly the amount of fluid taken or the amount lost through other channels than the kidneys, such as by sweating or vomiting. The oliguria that so commonly follows operations is usually due to these latter causes, and not to renal inadequacy.

As to the common methods of examining the urine, I have often been surprised at the frequency with which **albumin** is overlooked, even by supposedly competent examiners; and I have many times had occasion to demonstrate its presence, when it had been repeatedly reported to be absent—for instance, in cases of suspected calculus. This is usually due to using poor methods; perhaps quite as commonly, to using good methods poorly. Of the simple but accurate methods, I think potassium ferro-

cyanid and acetic acid the simplest and best; although those unskilled in its use often get poor results until they have become accustomed to the correct amounts to be employed. Boiling the upper portion of the urine in a pretty well-filled test-tube, adding a few drops of dilute acetic acid, heating again, and comparing the boiled and unboiled portions, is about equally accurate and is extremely easy. I would note, also, the frequency with which I have seen so-called nucleo-albumin confused with serum-albumin. Its significance is different, and it is important to determine how much of the reaction is due to it.

Further, I have been greatly impressed with the frequency with which doubt arises in testing for **sugar,** owing to an uncertain reaction to copper solutions; and with the infrequency with which this question is settled by the simple measure of using fermentation. In the same connection, I would mention the not uncommon occurrence of milk-sugar in the urine of pregnant or nursing women—a fact that has some surgical relations, and is frequently overlooked. That the copper reactions in such cases are not due to glucose is easily determined by the negative results of fermentation with ordinary yeast and of the phenylhydrazin test.

Doubt occasionally arises over the question whether **blood** is present; especially when the amount, at most, is small and the red cells, if present, have been destroyed. In such instances it is well to remember that the color of the urine is occasionally greenish, from the presence of reduced hemoglobin, and may not suggest blood. This point recently came up in a case that I saw with a surgeon, in which the color of the urine had led to much confusion. The determination whether blood is present is usually made quite readily by means of the hand-spectroscope or by chemical tests for hemoglobin, of which the most convenient are those of Heller and Rosenthal or the guaiac test (Schönbein-Almen). The source of the blood, so far as a direct examination of the urine in which it is found is concerned, can be told only by the physical condition in which it is discovered. Diffuse mixed blood suggests a high origin; ureteral blood-casts pretty clearly demonstrate that it comes from the ureters; while larger clots indicate a low origin. The association with renal elements, particularly renal blood-casts, is also indicative, of course, of a renal origin. Beyond these simple points urinary examination offers little direct help and an instrumental examination is necessary in order to demonstrate clearly the source.

When blood is present, the determination whether the albumin in the urine comes entirely from the blood or partly from a coincident nephritis is extremely difficult, and is often impossible. A search for casts and a general examination for the systemic signs of nephritis are the only reliable measures. I have no confidence in Goldberg's method of determining this point, which consists in counting the red corpuscles and comparing their number with the amount of albumin found by Esbach's method. The error inherent in the latter method, and especially the varying number of red cells that may have been destroyed, together with other important errors, make the measure of little value. Comparing the amounts of serum-albumin and of serum-globulin, which also has been

recommended as a method of settling this point, appears likewise to be of little value. The method, if accurately done, is too difficult for clinical use; and the results are likely to be very uncertain. When blood is present and there are noteworthy numbers of leukocytes also, the question whether there is suppuration in addition to hemorrhage may be settled, to some extent, by counting the red cells and the leukocytes, and determining whether or not there is a large excess of the latter. Unless the result is a very decided one, however, it should not influence one's conclusions.

The decision as to **whether there is renal or subrenal disease** is one that frequently needs to be reached; but it requires, I think, no special discussion here. Examination of the urine furnishes no royal road to an answer. It needs to be settled largely by a consideration of the symptoms, and by a general examination of the patient, examination of the urine helping almost solely through the simple measures of observing the reaction of the urine, noting the relative amounts of albumin and nucleo-albumin (much of the latter usually indicating subrenal disease, though nephritis may be present in addition), and observing the sediment for casts, pus, or large amounts of vesical epithelium. I have no faith in any one's ability to distinguish accurately in urine the epithelial cells from the kidneys, the pelves, the ureters, and other portions of the urinary tract.

It may be well to insist here that when **formed elements** are being looked for in the urine, and especially when there is any bacterial infection along the urinary tract, the examination should be carried out immediately after the urine is passed. Otherwise the formed elements may be very rapidly and completely destroyed. In cases in which bacterial infection is present,—as, for instance, in cystitis,—this undoubtedly occurs very frequently, even when the urine is examined at once, the formed elements being digested in the bladder.

A point that is of not uncommon surgical interest regarding **urinary sediments** is the frequency with which some of them, more especially oxalate crystals, produce severe irritation of the urinary tract, even when calculi are not found. This point appears to me not to be insisted upon sufficiently by most surgical or other writers. I have had repeated opportunity to see the temporary presence of many oxalate crystals associated with symptoms that could readily be, and sometimes were, mistaken for renal calculus, and even for appendicitis. This has especially occurred after immoderate indulgence in foods containing much oxalic acid, particularly rhubarb, though frequently due to other causes. It should be remembered that oxalate deposits, like most other deposits in the urine, are most frequently dependent, not upon the presence of an excessive amount of these substances, but upon other chemical conditions of the urine that cause precipitation. Therefore burdensome quantitative estimations of the amount present usually tell one nothing in regard to the local damage that oxalates, uric acid, phosphates, etc., may be doing. The point is of importance, also, in that it shows that the useful element in preventing local damage from such deposits is usually not simply measures

directed toward reducing the excretion of these substances, but those intended to favor their solution by properly altering the other chemical conditions of the urine.

Some further matters relating to the chemical examination of the urine in surgical cases need to be touched upon. Examination of the urine for **indican** is of occasional diagnostic value in doubtful cases of intestinal obstruction. In this condition, as is well known, an intense indican reaction occurs as a rule. This is ordinarily a matter merely of interest, but in doubtful cases it may be of diagnostic use. I recently saw, for example, an obscure case of intestinal obstruction in which there was some question as to whether the whole condition was not the result of a nephritis that was evidently present. A most intense reaction for indican was one of the points that favored intestinal obstruction. Operative relief of the obstruction produced rapid improvement in the nephritis, the latter proving to be secondary to the intestinal condition. An intense indican reaction may, however, occur of course from complete stagnation of the intestinal contents from any cause (as from peritonitis), and its presence does not indicate the cause of the stagnation. The best method for indican is the use of Obermayer's reagent.

The occurrence of **acetone, diacetic acid, and β-oxybutyric acid** in the urine has recently come to have particular surgical interest in connection with the intoxication that occasionally follows anesthesia, a condition that in this country has been especially studied by Brackett, Stone and Lowe,[8] Brewer, and James Kelly. It has become apparent that this post-anesthesial intoxication is associated with the presence in the urine of large amounts of acetone, diacetic acid, and their mother substance, β-oxybutyric acid. The general studies of the subject of acetonuria have shown that acetone, as well as diacetic acid and β-oxybutyric acid, is an evidence of an excess of acids in the system; that is, these substances indicate the presence of a form of acid intoxication.

Acidosis of this kind occurs in a variety of conditions, and as the result of a variety of causes. It may be due to great distortion of the diet, the chief elements in producing the condition in such cases being entire lack or great reduction of the carbohydrate foods and the use of large amounts of fats, especially certain kinds of fats; the protein food also probably adding to some extent to the acid-production. Such instances are met with chiefly in diabetes. Acidosis also occurs as the result of starvation, in which condition it is in large part, and perhaps entirely, due to the lack of carbohydrates, together with the tissue-destruction. The condition also develops, however, in the course of numerous other diseases; and sometimes, when definite disease is absent, it appears as the chief symptom in an obscure clinical picture of unknown cause. While in these latter varied instances the diet has sometimes been such as to make it appear to have been at least a contributing cause of the condition, this is often not the case; and the acidosis is then undoubtedly due directly to some disturbance within the organism of the sick individual. It has a particular tendency to occur in a marked form in certain special disorders, of which phosphorus-poisoning, acute yellow atrophy

of the liver, uremia, recurrent vomiting of children, and other gastro-intestinal disturbances and probably—from Whitridge Williams's observations—pernicious vomiting of pregnancy, are examples. It has an especially strong tendency to appear in children. One feature common to many of the disorders in which it occurs is tissue-destruction, particularly severe lesions of the liver; and this is probably in some way the direct basis of the acid intoxication.

The intoxication following anesthesia exhibits the evidences of acid intoxication, and the cases also show—at times, at least—hepatic lesions. It is probable, as Alonzo Taylor[9] believes, that these cases are due to what may be called a ferment intoxication. Many of the lesions in phosphorus-poisoning and acute yellow atrophy are known to be due to abnormal activities of the tissue-ferments. The acid intoxication is in such disorders a secondary matter, therefore; although it almost certainly intensifies the symptoms, and perhaps intensifies the original trouble also; for the activity of the autolytic tissue-ferments is favored by acids, as indicated by the work of Hedon and Rowland and others. The discovery of the acid intoxication and its treatment with alkali will, in some cases, cause improvement. The effects in post-anesthesial intoxication have not, so far as the treatment has been tried, proved satisfactory, and the chief result of discovery of the nature of the intoxication in this condition is at present, therefore, merely the important result of demonstrating the general character of the trouble in cases that develop these symptoms after anesthesia, and providing thereby an indication for eliminative measures.

The methods available to demonstrate acid intoxication by examination of the urine are a search for acetone and diacetic acid; and, if one has time and skill, an estimation of the ammonia of the urine and a demonstration of the presence of β-oxybutyric acid. In testing for acetone and diacetic acid the urine itself may be used at first; and if the result is negative, this suffices. If, however, the result is positive, the test should be tried again with the distillate. If this is done, I think that Gunning's or the sodium nitroprusside and the ferric chlorid tests are sufficiently reliable for clinical purposes. Errors are associated with their use; but they are reasonably reliable, if the distillate is used; and thoroughly reliable tests are, as a rule, impossible for the clinician to carry out.

Finally, I need to mention the tests of the urine for **pancreatic disease.** A number of these have been described, but only a few need discussion at present. I would say, first, that a test that I have myself previously stated to be promising, the estimation of the ethereal sulphates, is, I am now convinced, so uncertain in its results, when used for this purpose, as to be practically valueless. Much interest has been taken in *Cammidge's test* (see Vol. III, p. 1042), and by some persons much reliance has been placed upon it. The clinical results with it have been entirely unreliable in the hands of most skilful men. I believe that it has no clinical importance, but this is not yet fully settled. The search for a fat-splitting ferment in the urine in cases of obstruction to the flow of the

pancreatic juice, and particularly in acute pancreatitis, is rational in itself, and at present is perhaps deserving of more favorable consideration than any other special test we now have. The reported results from the use of *Opie's ethylbutyrate test* for this purpose have, however, been too few and too closely confined to cases suspected of pancreatic disease to permit of a rational recommendation of the test. It is certain that a negative result does not demonstrate the absence of pancreatic disease, even of acute pancreatitis. Whether a positive result is of any use as an indication of pancreatic disease cannot as yet be stated. For my own part, I must regretfully say that I place no reliance upon it. Before this test was described, I spent some time in attempting to perfect a similar test with the same objects; but I cast it aside, because I became convinced that the substances used in such tests for the ferment to act upon are so unstable that error is always likely to arise from this cause, and also because we have no justification for saying that a substance that will split the fat compounds used for this purpose is the pancreatic fat-splitting ferment. These objections hold against the ethyl-butyrate test; and unless a large mass of evidence had been accumulated in its favor, they would make me distrust the results from it. This evidence has not yet been accumulated.

I think that all urinary tests combined have little value in suspected pancreatic disease, as contrasted with careful clinical consideration of the cases. The only test that appears to me to have any real value is that for glycosuria, and this is in very many cases negative. If positive, however, especially if there are also certain fecal abnormalities present, the result adds decidedly to the evidence in any such cases.

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CHAPTER LVI.

SURGERY OF THE KIDNEY, THE URETER, AND THE SUPRARENAL GLAND.

By Joseph Ransohoff, M.D., F.R.C.S. Eng.,

CINCINNATI, OHIO.

TOPOGRAPHIC ANATOMY.

The kidneys, two in number, are deeply seated in the abdominal cavity in close relation to its posterior wall. They lie in niches on each side of the vertebral column, resting upon the anterior surfaces of the quadratus lumborum, the anterior layer of the lumbar fascia being between them. The upper end of each gland rests upon the corresponding pillar and the costal attachments of the diaphragm. The latter separates the left gland from the eleventh and twelfth ribs, and the right from the twelfth alone. The pleura above extends ordinarily down to the twelfth rib. Even when this is absent or rudimentary the pleura reaches to the last dorsal vertebra. The lower end of the kidney rests slightly upon the anterior surface of the psoas muscle, its lower pole being on a level with the third lumbar spine. In addition to a very considerable layer of loose areolar tissue containing a great deal of fat (tunica adiposa) which surrounds the kidney, there is posterior to this a well-marked fascia known as the retrorenal fascia, of considerable firmness. The outer layer of fat has been called the pararenal fat layer. Attention was first called to this double arrangement of the fat layers about the kidney by Zuckerkandl, and Gerota completed its study. Its importance is shown in describing the lumbar operation later. According to the latter, the "prerenal and retrorenal layers are formed by the splitting of the subperitoneal fascia of the abdominal wall at the outer border of the kidney."

The retrorenal layer passes inward between the perirenal fat in front, and the fascia covering the anterior surfaces of the quadratus lumborum muscle and its aponeurosis and the psoas magnus muscle behind. At the inner border of the psoas magnus it blends with the fascia covering the bodies of the lumbar vertebras and the intervertebral disks.

The anterior or prerenal layer passes in front of the perirenal fat between it and the peritoneum, and is continued inward just in front of the renal vessels, aorta, and vena cava to join the corresponding layer of the other side. Both the anterior and posterior layers are attached to the kidney capsule by fine fibrous bands, which pass through the perirenal fat, but the fascias as such have no direct attachment to the kidney. The retrorenal layer extends upward in front of the diaphragm and behind the kidney and suprarenal capsule, at the upper border of which

it is joined by the prerenal layer from in front, the two becoming lost on the diaphragm. Below the kidney the two layers approach each other but do not actually join, and, becoming thinner and thinner, are lost in the loose areolar tissue of the iliac fossa.

Beneath the two layers and crossing the posterior surface of the kidney obliquely from above downward and outward are the anterior branches

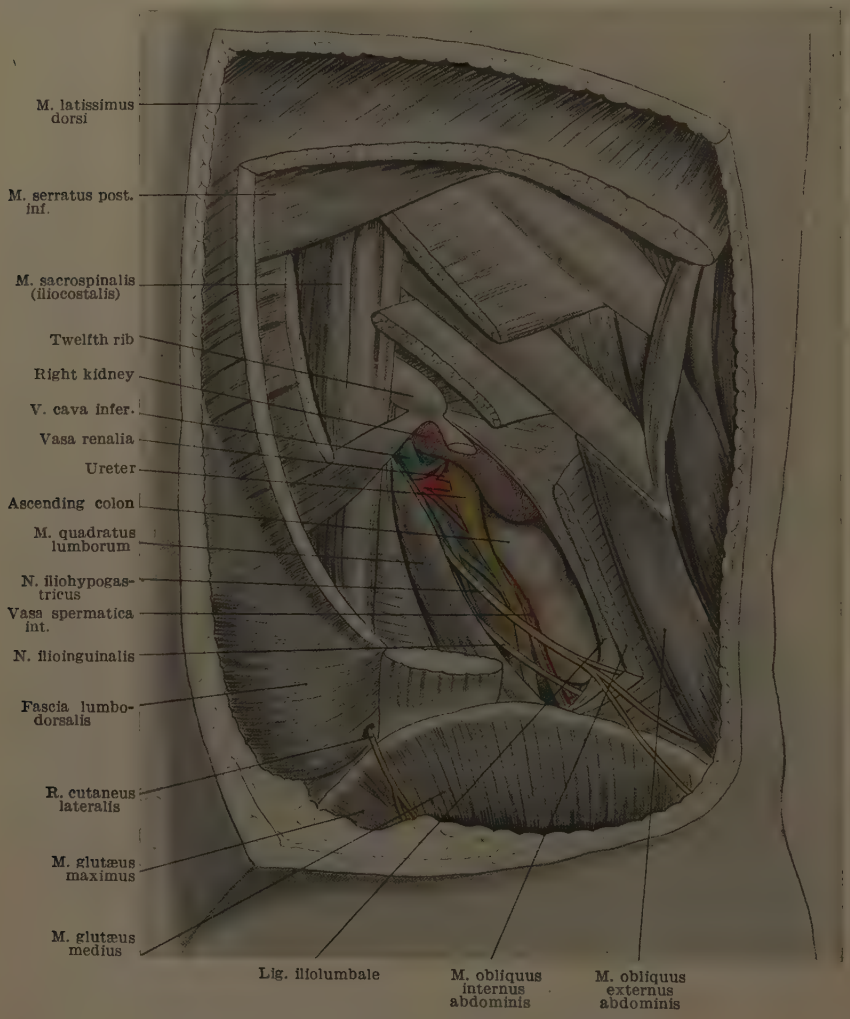


FIG. 111.—KIDNEY EXPOSED FROM BEHIND (Bardeleben).

of the last dorsal, the iliohypogastric, and the ilio-inguinal nerves. These relations account for the reflex pains in the groin and the scrotum in various forms of renal disease, for the contraction of the cremaster muscle, and the occasional development of herpes in or after renal seizures.

Although the lower half of the kidney projects into the costo-iliac

interval, unless considerably enlarged by disease or by reason of involvement of the retrorenal fat, a fullness in this region is not observed. In the same way absence of the kidney does not produce a sensible depression. The relation of the kidney to the last rib, and further within to the spinal transverse process, explains some extensive wounds of the kidney that have almost the appearance of contused and incised wounds as seen in other soft parts.

Anteriorly the right kidney is in relation from above downward with the postero-inferior surface of the liver, the descending duodenum, and the ascending colon. Quite to the inner side is the common bile-duct, away from any possible pressure from even great enlargements of the kidney. Enlargements of the latter by traction on the duodenum do at times give rise to jaundice by displacing the end of the common bile-duct. In the same way the loosening of the kidney from its moorings through its relations to the duodenum explains a set of phenomena that constitute the so-called renal crises, and it often gives the first impetus to gastroptosis. The relationship to the colon in the same way has an important bearing on the pathology of the vermiform appendix.

The left kidney has in front of it the fundus of the stomach, the lower margin of the spleen, the end of the pancreas, and the upper portion of the descending colon. Between the kidney and the parietal peritoneum run the blood-vessels and nerves to the inner margins of the respective segments of the colon. A careless division of this or protracted pressure, as from packing after an operation, has been known to produce fatal intestinal obstruction from paresis of the intestinal muscularis, or even complete gangrene. In renal enlargements the colon either retains its particular course in front of the kidney, giving a median or lateral area of dullness separated from each other by a band of resonance, or the colon is deflected inwardly, leaving a continuous area of dullness as far as the midline posteriorly.

Loosely placed in front of both kidneys are the coils of the small intestines, the mobility of which is such that when the left or right posture is assumed the lower end of the left or right kidney can often be palpated through the abdominal wall if it be thin and if the costo-iliac interval is large.

The kidney is closely surrounded by a strong fibrous capsule, which, although connected with the connective-tissue framework of the interior, is easily stripped from the surface. Slight bleeding follows such detachment. When deprived of its capsule over any considerable area, new adhesions form and the surface of the kidney where denuded assumes a roughly granular aspect, simulating cirrhosis of the kidney. The changes are very superficial, however, and do not extend below the subcapsular cortical zone of the gland, which in the normal condition contains no glomeruli. This capsule yields to gradual pressure from within. Sudden distention, as would result from acute obstruction of the ureter, or more rarely from the increase of blood-pressure in acute nephritis, is associated with great pain.

The hilum of the kidney, with the blood-vessels above and the pelvis

of the ureter below, lies on a level with the first lumbar vertebra. Owing to the positions of the aorta and the ascending cava, the artery is longer and the vein is shorter on the right side than on the left. The shortness of the right vein calls for particularly careful manipulation in removing the right kidney. The vena cava has repeatedly been torn. It also explains the greater frequency of neoplastic thrombosis of the vena cava in sarcomata of the right kidney. This vein is so short that the vena cava borders on the ureteral pelvis.

Each renal artery divides before reaching the hilum of the kidney into a primary ventral and dorsal branch, which sink into the sinus behind

FIG. 112.—SKIAGRAPH OF INJECTED KIDNEY, WITH WIRE IN URETER (Lamge).

the corresponding branches of the renal vein. Each of these gives off about five branches. As long ago as 1869, Hyrtl demonstrated by corrosion preparations that these anterior and posterior branches do not anastomose extensively. Wm. Keiller, Byron Robinson, and Max Brödel have made similar observations. In reality the kidney is naturally divisible into anterior and posterior segments or blades, the posterior the smaller, the blood-supply of each being independent of that of the other, after the vessels supplying them have been given off from the main branches of the renal artery. Between the two is the exsanguinated renal zone of Hyrtl. Along the convexity of the gland, therefore, the longitudinal section made nearer the posterior surface would be the least

likely to wound a large vessel. This line would correspond almost to the so-called Brödel line of Howard A. Kelly (Fig. 113).

The left renal vein is joined by the spermatic vein of the same side. A sudden onset of varicocele at an age when the disease is uncommon calls, therefore, for an examination of the kidney.

The renal pelvis, as seen in illustration, divides into two large branches for the upper and lower poles respectively. Through two incisions near the poles along the convexity the separated calices and the common pelvis of the kidney can be as methodically explored with the finger as can be the finger of a glove. The normal branching of the pelvis often gives form to the stone found within it.

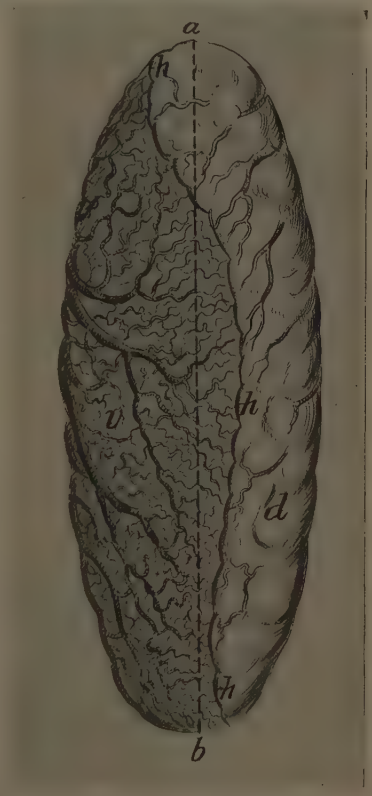


FIG. 113.—LEFT KIDNEY, LATERAL LONGITUDINAL BORDER (Byron Robinson).

a, *b*, Equatorial line of lateral longitudinal renal border; *d*, dorsal surface; *v*, ventral surface; *h*, *h*, *h*, indicate Hyrtl's exsanguinated renal zone, or the elective line of renal incision, located one-half inch dorsal to the lateral longitudinal renal border.

The **ureter,** about twelve inches long, beginning opposite the lower pole of the kidney, and about the size of a quill, passes downward and inward immediately behind the peritoneum to the brim of the pelvis. It is more intimately connected with the peritoneum than with the structures on which it rests, and in reflecting the former during operations the ureter usually adheres to it. As it crosses the brim of the pelvis the ureter is to the inner side, but near the attachment of the appendix. Pressure at this point in renal attacks gives rise to point tenderness, which might easily be mistaken for the tenderness of an inflamed appendix.

The pelvic portion of the ureter runs in front of the sacro-iliac joint above the obturator internus and its fascia, then leaves the pelvic wall to join the bladder. In the female it runs parallel with and a half inch or less from the uterine cervix, and after crossing the upper third of the vagina pierces the bladder opposite the middle of the vagina. A stone embedded in the lowest segment of the ureter can often be felt and removed through the vagina. Although seemingly of uniform diameter, the ureter presents three constant constrictions. The proximal is adjacent to the lower pole. The middle constriction is located where the ureter crosses the iliac vessels. The third constriction is at the lower ureteral orifice. The duct is narrowest at this point, where the circular fibers form a sphincter. Between these isthmuses

are dilatations or reservoirs (Byron Robinson). As Englemann showed thirty years ago, this sphincter is overcome by the rhythmic contraction of the ureter, in consequence of which a whirl of urine is forced into the bladder about every fourteen to twenty seconds. The loose connective tissue in which the ureter is embedded from end to end is rich in lymphatic vessels, which are significant in accounting for the ascending course of tuberculosis primarily seated in the genitalia of the male. The sensibility of the ureter is of a low grade. Smooth foreign bodies like a catheter are tolerated without causing great pain. Obstruction suddenly induced is associated with intense suffering, the result of distention of the capsule proper of the kidney.

MEANS AND METHODS FOR EXAMINATION.

The clinical methods for examination of the kidney for surgical purposes include, first, inspection; second, palpation and percussion; third, examination of the urine as a whole and of the separated urines; fourth, cystoscopic examination; fifth, ureteral catheterization; sixth, the segregation of the urines; seventh, cryoscopy; eighth, exploratory incision; and ninth, *x*-ray examination.

Inspection *per se* is, as a rule, of little value. When from some cause the kidney is considerably enlarged, or the retrorenal fat layer is involved in a suppurative process, a fullness of the loin is discerned by the trained eye. Only very large tumors cause an outward bulging of the lower ribs, as in empyema or enlargement of the liver and spleen. Although the latter, like renal growths, grow toward the anterior abdominal wall, they rarely project toward the loin.

Palpation.—This is the most valuable single method of recognizing an enlargement of the kidney, irrespective of its nature. While the normal kidney can often be palpated, every moderate enlargement is accessible to the trained touch. The examination should always be bimanual, and the position of the patient the dorsal recumbent, the lateral, or the reclining. Whatever the posture of the patient, the fingers of one hand are placed gently on the loin just below the last rib, and those of the other above the front of the abdomen a little above the line of the navel. If gentle efforts be made to approximate the finger-tips, the kidney, if at all enlarged, can be felt between them. If the patient takes a deep inspiration, the kidney can be forced between the examining fingers. In difficult cases the pressure should be continued for some time, that of the hand in front being directed upward and slightly outward. In patients in whom the muscular reflexes could not be otherwise overcome, I have found general narcosis a most valuable aid.

To elicit such point tenderness as is produced by a stone or a tuberculous focus, palpation with the thumb along the last rib from within outward and simultaneously on the two sides has been of great service to me.

Palpation enlightens us as to the size, position, and sensitiveness of the kidney. While the normal gland at times responds to pressure with a peculiar feeling akin to the testicular sense, palpation elicits pain when it harbors a stone, a pus focus, and to a less extent a tumor.

The only organ which by palpation could be mistaken for a kidney is the gall-bladder loosely joined to the liver and greatly distended. I know of one such case opened through the loin and emptied of its contents, including a number of gall-stones. It was the only case in

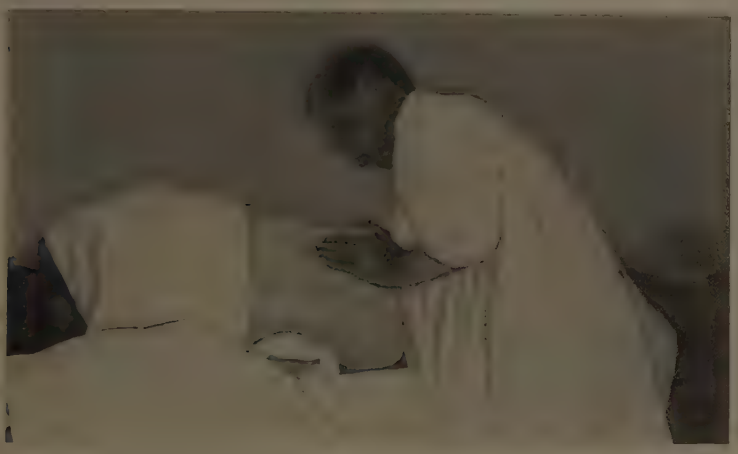


Fig. 114.—Palpation of the Kidney. Patient in the Lateral Position.

which I believed at the time that I had seen the *ballotement rénal* of Guyon.

Percussion is of value, and then only relative, when the kidney is

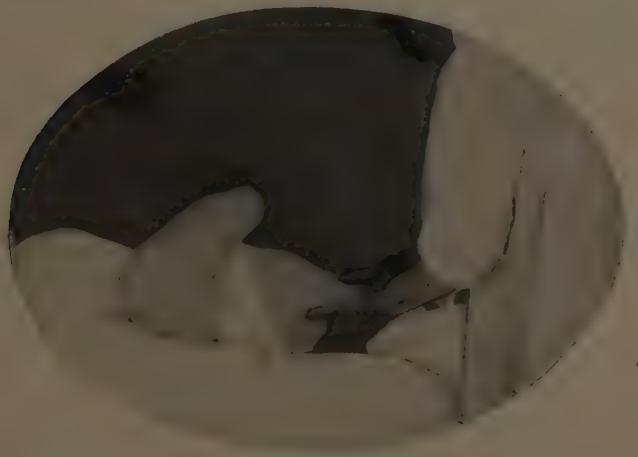


Fig. 115.—Palpation of the Kidney. Patient in Dorsal Recumbent Position.

enlarged twofold or threefold. If then the colon is distended, it can be outlined by percussion in front of and internal to the tumor. Enlargements of the spleen and of the liver do not present this relation to the large intestine.

Retroperitoneal growths springing from the lymph-nodes or non-pulsating ruptured aneurisms of the aorta may have the anatomic relations of renal tumors and cannot be distinguished from them except by other clinical symptoms or by exploratory operation.

Examination of the Urine.—Surgical affections of the kidney sooner or later show changes in the urine, either in quantity or quality or both. To discover them repeated examinations at varying intervals must be made. The frequency of micturition must also be considered, for great increase thereof (thamuria) is often associated with renal diseases, especially tuberculosis. The frequency due to excessive quantity must again be distinguished from that of irritation. Whereas the latter may be of renal origin, it is much more likely to be vesical in character.

Oliguria and anuria are generally associated with serious and particularly acute ascending infective processes. They are also present in unilat-

FIG. 116.—COMPARATIVE EXAMINATION OF BOTH KIDNEYS.

eral retention, as from an impacted stone or twist of the ureter, and after nephrectomy until compensation of the kidney is established. The decreased excretion is largely a reflex manifestation on the part of the kidney not primarily affected. Experimental tying off of one ureter in animals is invariably fatal. The reduction of the quantity of urine excreted may be progressive and terminate in complete suppression. This condition may continue for twenty-four or forty-eight hours or even longer without producing toxic symptoms. After the third or fourth day uremia develops and death, as a rule, follows by the end of a week. In the celebrated case of Polk death resulted after eleven days of complete anuria following the removal of a solitary kidney.

Polyuria.—This is generally observed with increased frequency. It is often seen in chronic surgical affections of the kidney. It often indicates the presence of interstitial changes added to the grosser ones, as in chronic nephrolithiasis. It is quite common in infected lesions of the

pelvis, as in post-typhoid pyelitis. It may also result from backward pressure of prostatic disease. In primary renal tuberculosis it is very common.

Changes in the composition of urine due to the presence of abnormal constituents can practically always be found in surgical affections of the kidney. That does not include albumin, sugar, or urinary casts, since, as has already been stated, interstitial changes often follow in the wake of surgical conditions. Nor ought more than allusion be made here to the various crystals, amorphous salts, epithelia, and micro-organisms that must be searched for in every urinalysis. Blood and pus are the constituents of urine oftenest found in surgical diseases of the kidney and ureter. To determine their origin is of prime importance.

Hematuria varies in degree within very wide limits. As will be seen later in considering individual diseases, the blood contained in the urine may be so slight as to leave the urine entirely clear and limpid. This is often true of stone in the kidney. The microscope will reveal a few cells, almost colorless—little more than shadows. In profuse bleeding the urine presents a smoky appearance and a brownish sediment on standing. This sediment must not be mistaken for that of hemoglobinuria, which consists of amorphous brownish, granular pigment masses, arranged at times in irregular clumps or cylindric figures, and containing few if any red blood-cells. Hemoglobinuria is not associated with surgical diseases of the kidney. Clots, often expressed with colic, may be found when the bleeding is very profuse, as from severe laceration of the kidney or in cases of sarcoma growing into the pelvis. The form of the clot as molded by the ureter, particularly if it has been partly decolorized by prolonged retention therein, has considerable diagnostic value. In a general way it may here be stated that the severity of the hematuria increases in the diseases in the order named: stone, tuberculosis, essential hematuria, trauma, and neoplasm. The onset of the hematuria is often significant of its cause. If it follows a renal colic or violent exercise and disappears with rest, it speaks for stone. If associated with pyuria or dysuria, it points to tuberculosis. If it occurs suddenly and is very profuse, it indicates the presence of a tumor. As a symptom of chronic nephritis hematuria is not rare.

It sometimes is difficult to determine the origin of the hematuria in the absence of other clinical symptoms. If, after having thoroughly washed out the bladder, nearly pure blood escapes with the last of the water injected, the bleeding is probably of vesical origin. Sudden cessation of bleeding with as sudden return speaks for the renal origin of the blood. If the blood-corpuscles are very pale or crenated, or more or less fragmentary, it is almost certain that they come from the kidney. This breaking up of the corpuscles is due, as Gumprecht has shown, to the prolonged action on them of urea. If the urine is smoky or of uniform color when passed, the kidney is probably at fault. But clots formed in the kidney may be passed at the end of micturition, as are those formed in the bladder. In many cases a cystoscopic examination is necessary to determine the source of the bleeding.

Pyuria.—This is easily recognized by the cloudy appearance of the urine and the yellowish deposit when sedimented. This may be so slight as to be demonstrable only by the centrifugal machine. Bacteriuria must not be mistaken for pyuria; the appearances of the urine are very much alike. As in hematuria, it may be difficult to determine the source of the pus. The view formerly entertained that acid urine containing pus is of renal origin is no longer tenable. Pyuria of vesical origin shows an acid urine until retention causes its decomposition within the bladder. Of very great value is the observation of Senator that a preponderance in the sediment of mononuclear cells bespeaks the renal origin of pus. Long ago Thompson suggested that in doubtful cases the bladder be flushed with water until this returns perfectly clear; the catheter is then clamped for ten minutes. If the urine then escaping is cloudy, the pyuria is of renal origin. Systematic pressure on the kidney may increase the turbidity.

Characteristic of renal pyuria is the rapid or sudden disappearance of the pus with marked aggravation of symptoms. The passing of urine, normal in quantity, then establishes the integrity of the other kidney. Unfortunately, this combination of symptoms is not often encountered.

Cystoscopic Examination.—In all obscure surgical affections of the kidney, and invariably before the removal of a kidney is to be done, a cystoscopic examination should be made. By means of it we can, with few exceptions, determine whether the bladder or the kidney is the seat of the disease. The exceptions are cases in which, as in advanced tuberculosis or from previous maltreatment based on faulty diagnosis, the bladder as well as the kidney is involved. When the former is much contracted, whatever the cause, a cystoscopic examination is contraindicated and may do considerable harm. This examination in a relatively healthy bladder will reveal the condition of the ureteral orifices and in most cases permit the direct observation of the whirl of urine rhythmically ejected from each kidney. A little blood-clot or a flake of pus is not infrequently observed in the ureteral orifices and at once helps in doubtful cases to fix the site of the lesion. Hurry Fenwick has called attention to the value of ureteral meatoscopy in the diagnosis of renal disease. If the orifice of the ureter appears considerably elongated, it speaks for some dilatation of the kidney, whether from blood, pus, or urine. A golf-holed orifice is often seen in tuberculosis, unless there have been repeated renal colics, when a conical protrusion of the mucosa is seen, such as is common in kidney stone. The appearance of the mucosa just below the ureteral orifice often shows the effect on it of the abnormal urine from the affected side in the shape of increased vascularity, of erosions or ulcerations of greater or less depth. The presence of two ureteral orifices should always be carefully looked for, since in the vast majority of cases they speak for the presence of two kidneys that are distinct. A horseshoe-shaped or a placental kidney generally is furnished with two ureters. In congenital absence or atrophy of one kidney the ureteral orifice of that side may still be present. Of course, no efflux of any kind will then be seen. (For full consideration of the subject of cystoscopy, see p. 282.)

Ureteral Catheterization.—Whereas this and cystoscopy are elaborately considered elsewhere, it must be alluded to at this place. Ureteral catheterization is a most valuable aid in the diagnosis of obscure surgical affections of the ureters and kidneys. In the hands of experts it permits the recognition of the presence of two kidneys and of the amount and character of urine excreted by each. It may reveal strictures of the ureter or calculi impacted within them.

If, as was simultaneously devised in 1899 by A. B. Johnson, of New York, and Lowenhardt, of Berlin, ureteral catheterization be combined with radiography, additional certainty as to the presence of two kidneys and their relative functional values can be obtained. Unfortunately, ureteral catheterization is not always feasible in the hands even of experts. In tight urethral strictures and great hypertrophy and vascularity of the prostate gland it may be impossible to use the cystoscope at all. In other cases there is no assurance that an abnormal condition of the bladder will not prevent the ureteral orifices from being brought into view. Furthermore, where there is an infected condition of the bladder, ureteral catheterization is not devoid of danger. Its great value rests on the certainty with which each kidney can be drained of its excretion and its functional capacity established. Ureteral catheterization with cryoscopy affords the surest method of establishing the respective values of the two kidneys. Since in practice this must be known only in those cases in which nephrectomy is contemplated, ureteral catheterization need not be practised as a routine method for the diagnosis of surgical conditions of the kidney. (See p. 288.)

Segregators.—Before ureteral catheterization became, with limitations, the accepted method for functional renal diagnosis, various efforts had been made, by unilateral compression of the ureter, to secure the secretion of the other kidney. By compression from within the bladder, or from without, even to the extent of temporary ligation of the ureter, it was sought to separate the urines. Where ureteral catheterization is not feasible or is contraindicated, the separation of the urines by one of the various segregators should be tried. Various forms of segregators are pictured and described on pp. 279–282.

When the segregator works well, it separates the urines perfectly. It can be used in cases where ureteral catheterization is contraindicated or impossible. It has its limitations. It cannot be used when the bladder is greatly contracted. When its mucosa is at all involved, it is almost certain to cause bleeding, which vitiates the results. When the trigonum is distorted by ulceration, by swelling of the mucosa, or by prostatic enlargement, the establishment of a median septum by any segregator may not be possible. As compared with ureteral catheterization for diagnostic purposes, the writer believes that the use of a segregator is to be preferred as a routine practice. It requires less experience and can do less harm. It does not, however, give the same accurate information as to the condition of the ureters. The technic of the application of segregators is given on p. 280–282, and here also are pictured various forms of the instrument.

Cryoscopy.—Until very recently our knowledge of the functional capacity of the kidneys was obtained from the total daily excretion of urea. In health and under varying diet this is between 25 and 35 gm. A reduction to 15 gm. or under for the daily average indicates such a loss of functional capacity that a serious operative interference would probably be followed by death from uremia. In every case in which Kümmel extirpated the kidney the total of urea excreted exceeded 16 gm., and in all of his cases the remaining kidney assumed full function. When, therefore, the separation of the urines is impracticable, much may be assumed regarding the post-operative probabilities from the quantitative analysis as to urea. It, in conjunction with cryoscopy of the blood, is a valuable aid.

When separation of the urines is feasible, a comparison of the percentages of urea of each furnishes an index of the proportion of the combined work each kidney is doing.

Cryoscopy is based on the study of V. Koranyi of the freezing-point of the blood and of the urines combined or separated. To estimate the molecular concentration of a fluid, its freezing-point or cryoscopic index is determined. If the kidneys do insufficient work, there is an accumulation of the waste products of tissue change in the blood, thereby increasing its molecular concentration; with this there is a corresponding fall of the freezing-point. The normal freezing-point of the blood is .56° below that of distilled water. This index is fairly constant with sufficient kidney function. It may be influenced by a variety of pathologic conditions remote from the kidneys, such as produce deficient oxygenation of the blood, anemias, hemorrhages, and so on. The fall of .03° to .05° is evidence that both kidneys are acting insufficiently. If the cryoscopic index is much below this, nephrectomy ought, according to the advocates of this method, not be performed.

The cryoscopic examination of the urine gives results less constant than those of the blood, because of the wide variation in its organic and saline composition. The freezing-point of urine is from 1° to 2.3° below that of distilled water. If from defective excretion the number of molecules is diminished, the freezing-point rises. If under an ordinary regimen of fluids and solids the index is less than 1° below that of water, insufficient renal capacity may be assumed. To be of greatest value cryoscopy must be made of the blood and of the separated urines.

Kümmel, from an enormous experience of over one thousand examinations, attaches the greatest importance to cryoscopy, particularly of the blood, in estimating the functional capacity of the kidney. Before using the method forty-one nephrectomies were followed by fifteen deaths. After instituting ureteral catheterization and cryoscopy, one hundred and forty-eight nephrectomies were followed by ten deaths—a mortality of 6.7 per cent.

Cryoscopy of the blood is of great prognostic value in cases of prostatic hypertrophy in which there are as yet no demonstrable changes in the kidneys. A marked elevation of the blood concentration, often to .71°, marks a speedy dissolution. In children with tuberculosis of the kidneys

and bladder, where cystoscopy often may be impracticable, cryoscopy of the blood gives an accurate index of the advisability of operation.

Albarran, like Kümmel, Casper, and Rumpel, is a forceful advocate of ureteral catheterization and the quantitative analysis of the separated urines. To test the comparative functional capacity of the two glands, the urine must be collected for at least two hours at a time. Albarran allows the catheters to remain in place for hours. In two cases he retained them respectively fifteen and forty-five days. After one hundred and sixteen nephrectomies he had only five deaths.

Artificial Glycosuria.—Four years ago Casper and P. F. Richter utilized v. Mering's observation of the sugar-excreting effect on the kidneys of the subcutaneous injection of a minimal quantity of phlorizin (0.01). The sugar appears in the urine, as a rule, in less than thirty minutes and continues about three hours. The rapidity of its appearance in the combined urines or the compared rapidity when the urines are separated is an index of the functional renal capacity. Kapsammer in over two hundred observations confirms the value of this test. Two years ago Voelker and Joseph introduced a method which is less circumstantial than cryoscopy and the phlorizin test. After the injection of 4 c.c. of a 4 per cent. solution of indigo-carmin into the gluteal region, cystoscopic examination reveals a colored stream from the ureteral orifices of the normal kidney. Combined with segregation with Lambotte's instrument, I have obtained some good results from the internal administration of methyl-blue.

In opposition to the opinions above quoted in regard to cryoscopy and separation of the urines are those of Israel and Rovsing, who insist on the unreliability of all methods, and with a good deal of reason ascribe the reduced mortality to earlier diagnoses and, therefore, earlier operations, and to improved technic.

From any and all of the above methods, when practicable, such precise knowledge can be obtained that the only kidney need never again be removed. In cases in which nephrectomy is not contemplated, the more complicated methods need not be practised. A careful examination of the clinical history, the symptoms, urinalysis, and cystoscopy are all that is needful. When nephrectomy is contemplated, every effort should be made to determine the actual functional capacity of each kidney. But, after all, the examinations only show this for the time being; they cannot determine the potential capacity of the organ remaining after operation. Reflex anuria may develop after nephrectomy when gross and microscopic examinations show the other kidney to be normal in every regard. Jemckel recently reported a case in which ureteral catheterization and cryoscopy demonstrated a normal functionating kidney. The patient died after nephrectomy, and the autopsy revealed a normal gland. One such case throws a doubt upon the infallibility of the modern methods of functional diagnosis. It disproves the dictum of Albarran, "Un opéré de néphrectomie ne doit pas mouroir d'insuffisance rénale."

Exploratory Incision.—As a result of the refinements of the modern methods of determining the functional value of each kidney,

exploratory incision to determine the presence and gross anatomic condition of the other kidney is practised less often than formerly. To the great majority of surgeons ureteral catheterization and the complicated chemical analyses above alluded to will remain an unattainable method. Even the most expert meet with failures. Here a short median incision above the umbilicus for exploration is indispensable. Through it the other kidney can be located and palpated by bimanual touch, with the fingers of one hand in the abdomen and those of the other in the loin. While it is true that a tuberculous kidney or a pyelonephrotic kidney need not be much enlarged, and that one compensatorially enlarged may appear abnormal, in the overwhelming majority of cases a kidney that is felt to be of normal size and consistence will in time do double service after its fellow is removed. Such an exploration takes but a few minutes and is imperative unless the condition of the other kidney has been fixed by other methods. An exception may sometimes be necessary in the grave emergency arising from a severe rupture of the gland. The abdominal route is preferable to the lumbar for exploration. This has the advantage of bringing the kidney into view, but requires a more extensive dissection and more time. Errors, of course, are possible, but it is a fair assumption that a kidney normal in size, consistence, and place has a normal potential capacity.

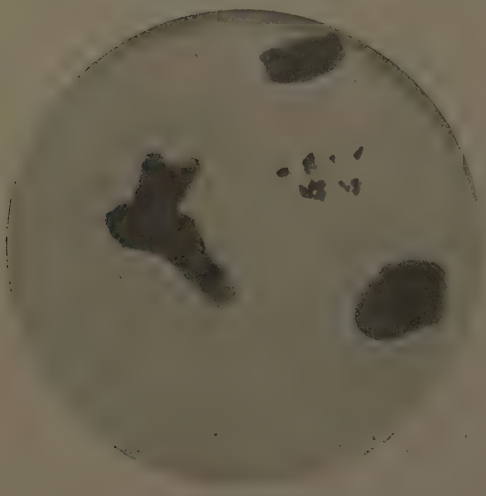


FIG. 117.
1, Coral-shaped stone in pelvis of kidney; 2, guttered ureteral stone; 3, urate stones weighing nine grains.

In suppurative and retention processes, where nephrectomy is contemplated as an alternative method, it would be proper as a last resort to establish a pelvic renal fistula, through which all of the urine from the affected kidney can be withdrawn and compared with the bladder urine from the other side. The method was first suggested by Czerny. The fistula to be of diagnostic value must be of ample size to prevent the escape of any urine into the bladder.

x-Ray Examinations.—With the advent of radiography certainty in the diagnosis of many surgical affections of the kidney and ureter, especially stones, was greatly furthered. To obtain a satisfactory plate is still one of the difficult feats of radiography. But when such an one is obtained, it should show the last two ribs, the transverse processes of the lumbar vertebræ, and the shadow of the psoas muscle clearly. In such a plate the shadow of even a normal kidney may often be seen with proper illumination. As an adjuvant in determining the presence of a second

kidney this shadow is valuable. In enlargements from tumors or retention, a positive shadow can almost always be obtained.

If the *x*-ray plate is a good one, the presence of a stone is revealed by a distinct sharp shadow, showing itself in exactly the same shape and position in every successful exposure of the patient. The technic of radiography of the kidney has been so far improved that great certainty attaches to the results obtained. Although subject to occasional errors, the radiographic presentment of a stone must be considered the only

Fig. 118.—Calcareous Deposits on Ligatures after Salpingo-oöphorectomy.

positive proof of its presence before operation. It is a *sine qua non* for a positive diagnosis. It can ordinarily be obtained irrespective of size, situation, or chemical nature of the stone, and of the degree of corpulence of the subject. The absence of a shadow in a number of successful plates is by many, following the teaching of Leonard and Rumpel, considered sufficient to make a negative diagnosis as to stone. Even great obesity does not preclude the probability of a reliable plate.

Leonard reports three hundred and thirty-one examinations for

kidney stones with only 3 per cent. of failures. From Kümmel's and Rumpel's eighty-four cases of renal stone, sixty-five positive results were obtained after the technic had been perfected. Altogether, three hundred and twenty-eight *x*-ray examinations were made. In almost every instance the shadow of the stone in form and size is like the stone found at the time of the operation.

The ease with which the rays penetrate a stone varies according to the chemical composition. The hard stones formed by the oxalates are penetrated with the greatest difficulty, and, therefore, are most easily located by radiography. Uric-acid stones are a little more difficult to find by reason of their greater permeability. Phosphatic stones, on

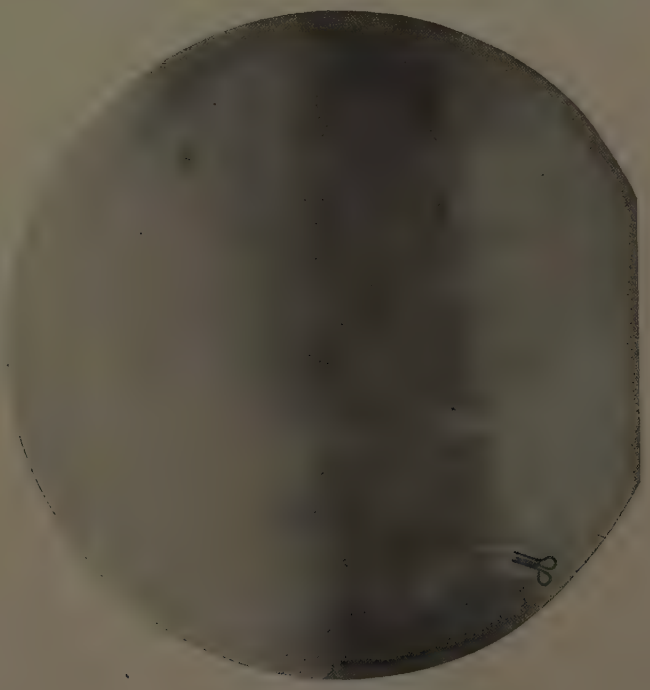


FIG. 119.—STONE IN PELVIS OF KIDNEY.

account of their lightness, are most permeable of all, and unless containing a great deal of lime, they show only the faintest shadow.

The interpretation of even the best *x*-ray plate may be faulty. In one of the cases of the writer, three separate plates showed four stones to be in the renal pelvis. The operation revealed about thirty small stones so closely packed together in the pelvis as to appear as four stones in the picture. A shadow in the renal pelvis or in the track of the ureter can positively be looked upon as a stone in the urinary tract only when it is associated with other clinical evidence. Misinterpretation of shadows has been sufficiently common to warrant this dictum. Calcified lymph-nodes, phleboliths, the thickened tip of an appendix, have been mistaken

for renal or ureteral concrements. Buried sutures infiltrated with lime salts after previous laparotomies, particularly for appendicitis, have been mistaken for ureteral stone. In a patient seen with Barrow, of Lexington, I saw the presentment of seven or eight small stones on one side and two on the other in the track of the pelvic portion of the ureter after the removal of the appendages (Fig. 118). If radiography of the calculus can be combined with the use of a ureteral catheter, as first recommended by Tuffier and Fenwick, such sources of error will be eliminated. Instead of using a metal mandarin for the catheter, Helferich (Goebel) has made use of a catheter the varnish of which contains some vermilion.

Very recently Vogel and Lichtenburg have shown some very excellent *x*-ray pictures of dilatations, twists, and displacements of the pelvis and the ureters by injecting into them a 2 per cent. to 5 per cent. solution of collargol. The injections are usually associated with pain which lasts for twenty-four hours. This alone will probably prevent the method from achieving a wide success. In the technic of radiography of the kidney an empty condition of the intestine is a first requisite. Free purgation for one or two days must be practised. The best pictures are then obtained, if one of the various diaphragms be used. Where a more extensive picture is desired for general study, compression of the abdomen with a wide band, preferably attached to the table, is essential. When the diaphragm is used, exposures must be made successively and of different parts in order that no part of the urinary tract may escape the skiagraphic examination.

CONGENITAL MALFORMATIONS OF THE KIDNEY AND URETER.

Anomalies of position, form, and number of the kidney and ureters, which until recently possessed only scientific interest, are far from rare. Aristotle knew that life was compatible with one kidney. Instances of congenital absence of one kidney were described by Vesalius, Eustachius, Baubin, and Haller. Congenital abnormalities may be divided into three groups: First, abnormalities of number; second, abnormalities of form; and third, abnormalities of position.

Abnormalities of Number.—Entire absence of one kidney is quite rare. According to Morris, congenital absence of one kidney is to be looked for once in every two thousand and fifty cases. A tabulation of two hundred and thirteen cases has been made recently by Ballowitz. Mankiewicz added twenty-one new cases. Winter gives a total of two hundred and thirty-seven cases. The kidney was absent in ninety-eight on the right side and one hundred and twenty-nine on the left. It seems twice as common in men as in women, perhaps because autopsies are more frequently made on them. The renal vessels are generally absent or very rudimentary on the side of the defect. Of one hundred and eleven cases in which the suprarenal bodies were looked for, they were found absent thirty-one times. In ninety cases they were present, and in sixty-seven normal in position and form (Ballowitz). Anomalies of the genitalia were often associated with kidney malformations. They are oftener

found in women than in men. In them there have been found the uterus unicornis and atrophy or absence of the ovary. In men the vesicula seminalis and vas deferens of the same side are often absent. Absence of the testicle was observed only four times, although it was very frequently atrophic.

Of greatest importance is the status of the ureter in these cases. In most of them it was not found. In eighteen cases it was present in its lower part in a very rudimentary form and permitting the introduction of a probe for a short distance. In five cases the ureteral orifice appeared as a slight depression. In all other cases of congenital absence of the kidney the ureter was absent, as was also the ureteral orifice. In five cases the solitary ureteral orifice was in the midline. The importance of this in cystoscopic examinations is self-evident.

For practical purposes **congenital atrophy of the kidney** and that acquired in early life must be considered with congenital absence. Rudimentary and atrophic kidneys usually retain, however small, their lobulated form, and the ureter of that side is in evidence almost always.

In congenital absence or atrophy of one kidney the remaining gland is ordinarily decidedly enlarged. In only a few cases was the kidney found of normal size and in only five cases smaller than normal. In sixty-three of two hundred and thirty-six cases the solitary kidney showed pathologic changes. Various forms of calculi were found in nineteen cases, or 8 per cent. of all solitary kidneys contained stone. There were twenty-one cases of various forms of chronic nephritis. Tuberculosis, hydronephrosis, and neoplasm were observed in the rest of the solitary kidneys. There are records of eleven operations on solitary kidneys—four nephrotomies and seven nephrectomies. The nephrectomies were fatal in from one to eleven days. The case of Polk lived eleven days.

Abnormalities of Form.—The most common malformation is that in which there is a fusion of the two organs into one large gland mass. The horseshoe kidney is the common form of fusion. In it the lower poles are united either by gland tissue or more or less dense bands of connective tissue. The concavity looks upward. Fusion of the upper poles is very rare (Fig. 120). According to Robinson, the isthmus is above in only 7 per cent. In the great majority of cases the isthmus is located in front of the aorta, although in fusion of the proximal poles the isthmus is found behind the aorta somewhat more frequently. The renal bridge is placed in the middle line, and two pelves are, as a rule, present and placed anteriorly. The pelvis of each half very often divides high in the hilum of the kidney, so that the number of ureters is double. The two ureters from each side are, as a rule, fused before entering the bladder, so that a single orifice appears for each side in the bladder. From a more or less extensive union at one extremity, the fusion may be continued upward until, in the most marked cases, the fused glands present the appearance of a placental body with a single or double pelvis, but with separate ureters. The literature presents a number of cases in which operations, often including partial nephrectomies, have been successfully performed on the horseshoe kidney.

A positive way of recognizing fusion of the kidneys does not exist. One may suspect it when a tumor clinically shown to be connected with the kidney has a central situation and perhaps, according to Davidson, transmits the pulsation of the abdominal aorta. Steele reports a large fused kidney recognized by exploration. The *x*-ray pictures showed the presence of two ureters.

Supernumerary kidneys are extremely rare. Watson Cheyne reports the presence of a third kidney, with its own ureter and blood-supply, discovered by laparotomy. It was well developed, of normal size, and from three to four inches distant from the right kidney. Far more common than a third kidney is a double ureter and pelvis on one or both sides. Byron Robinson made a study of thirteen specimens. When the kidney

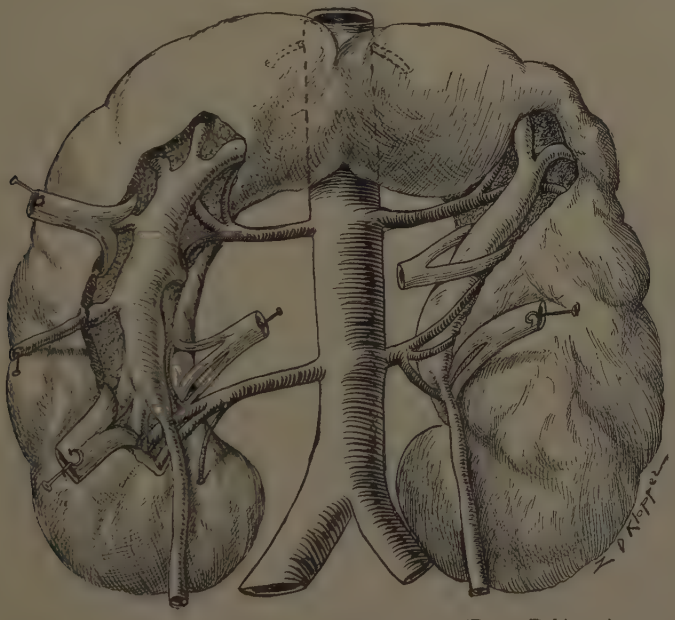


FIG. 120.—HORSESHOE KIDNEY; ISTHMUS ABOVE (Byron Robinson).

possesses two ureters, the one connected with the upper pole habitually crosses behind the other ureter and terminates in the opening furthest from the ureteral orifice. Bransford Lewis has skiagraphed such a case, showing a lead fused wire in the catheters (Fig. 121). Hammerschlag demonstrated by methyl-blue test bilateral duplication of the ureters.

Abnormalities of Position.—Although the fused and solitary kidney are, as a rule, in an abnormal position, an otherwise normal kidney may be congenitally displaced. Strater has collected fifty-nine cases of renal dystopia, many of which were operated upon. The displacement may be in a downward or lateral direction. The latter may be so extreme that the two kidneys are on the same side. The kidney may also be rotated on its axis. It may be arrested at any point

in the course which it must travel in embryonal life from the pelvis to the lumbar region. In most instances the displaced kidney with a short

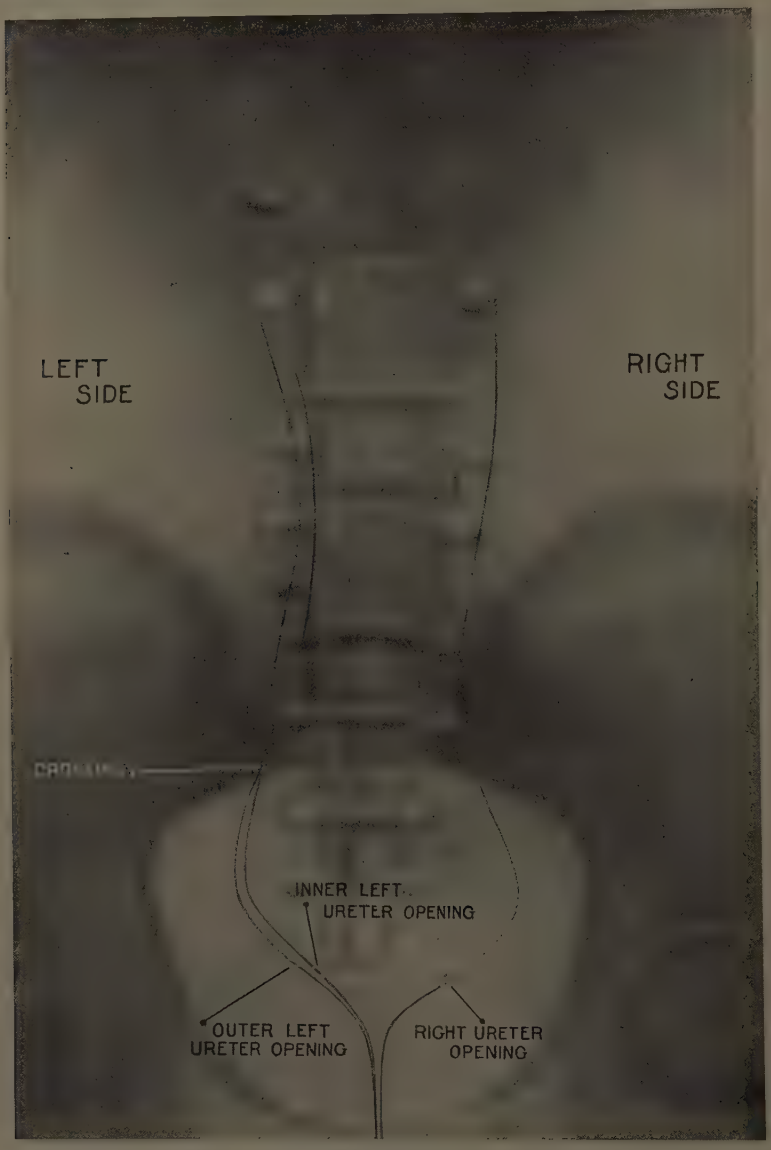


FIG. 121.—BRANSFORD LEWIS'S CASE OF THREE URETERS DEMONSTRATED DURING LIFE BY URETERAL CATHETERIZATION AND RADIOGRAPHY.
Gonorrheal infection of one of the three ureters. Permanently relieved by ureteral lavage.

ureter has been found in the lesser pelvis, fixed by a peritoneal fold to the lateral wall, or in the hollow of the sacrum. Mobile dystopic kidneys, although rare, have been described. The apparent preponderance of

the pelvic over abdominal dystopia is due to their being recognized oftener on account of their serious pressure effects, particularly in women during gestation and parturition.

The arteries of the displaced kidney are generally anomalous and come from the common and internal iliac in the pelvic form, and very near the aortic bifurcation in the abdominal. This anomalous blood-supply distinguishes the congenital from the acquired displacements even when in the latter the kidney has become fixed. In all reported cases the suprarenal gland was in its normal position.

The clinical features of an otherwise normal renal dystopia are those common to chronic pathologic conditions of the pelvis in women. They are a sense of weight in the lower abdomen, pains often reflected to the coccyx or the thigh, pain in cohabitation, and quite often menstrual disturbances and marked obstipation. Abortions often result from a dystopic kidney. In two cases of Hochenegg and Israel marked psychic disturbances were observed.

The **diagnosis** of a normal dystopic kidney has in a vast majority of cases not been made, except by exploratory incision or during an operation for the removal of a pelvic tumor. In seven cases it was not known that a nephrectomy was being done until the operation was completed. In two it was a solitary kidney. When pathologic changes, chiefly hydronephrosis, pyonephrosis, or neoplasms, develop, the diagnosis is facilitated by the clinical phenomena belonging to them. Although ureteral catheterization, by demonstrating the shortness of the ureter, may, as it has, in some cases, make the diagnosis probable, for the most part an exploration will be needed to determine the nature of the condition.

A **treatment** of congenital dystopia is indicated only in cases in which there are marked pressure effects or pathologic changes. In cases of distention and of tumor, nephrectomy alone should be considered. Although this can be accomplished in the pelvic dystopia through the sacral route, as recommended by Hochenegg and Tillmanns, removal by laparotomy is to be preferred. In one case Israel, after making the diagnosis by median laparotomy, by a subsequent operation removed the kidney through a lateral operation. If the dystopic kidney is normal, an effort should be made to fix it in the iliac fossa, care being taken, of course, that harmful tension is not made on the ureter and the vessels. Successful cases of such transference have been recorded by Frank, Strater, and Delaforge.

Anomalies of the Ureter.—Without involvement of the kidney proper the ureters and the pelvis are subject to many anomalies. A divided pelvis with duplication of the ureter for half of its course is found in about 1 per cent. of all subjects. The origin of the ureter may be from the upper end of the pelvis, with a consequent tendency to valve formation and obstruction to natural drainage. In a number of instances an anomalous course of the renal vessels has caused obstruction of the proximal ureteral end and hydronephrosis. In one case Israel revealed this condition by operation. Anomalies of insertion of the lower end are more common. The insertion may be in any part of the

bladder wall, the prostatic urethra, or seminal vesicle. In women, usually with other developmental defects, a ureter has been found to empty into the urethra, the vagina, or the rectum. Cystic dilatation of the lower end has been described particularly by Englisch, who collected fifteen cases. This condition has in a number of cases been recognized by cystoscopy and relieved by suprapubic section and resection of the anterior wall (Garrè). Congenital intravesical prolapse of the ureter occurs in the form of more or less pouching into the lumen of the bladder. While ordinarily the pouch is small, it may project in females so far as to appear at the urethral orifice. Blumer has collected thirteen cases, of which ten were congenital. Congenital strictures of the ureter, even to complete occlusion, have been found chiefly at the normal isthmuses. They are sometimes in the form of valves, and are found at the beginning of the ureter, near the pelvic brim, or in its course in the bladder wall. The effects of these anomalies on the kidney will be considered in the section on Hydronephrosis. The diagnosis of abnormalities of the ureter cannot be made unless secondary dilatation of the ureter or renal pelvis occurs. Anomalous insertions into the bladder can be recognized by cystoscopy. The entrance of the ureter into the rectum, since it is incompatible with life, is not of surgical interest. When the ureter opens into the urethra, vagina, or seminal vesicle, incontinence is, as a rule, present, and then operative measures must be resorted to.

The cure of these conditions involves an operation which must vary in the individual case. For distention of the lower end of the ureter and for prolapse an intravesical operation will almost always be indicated after suprapubic cystotomy has been made (Garrè). In a number of cases the operation has been successfully done with the operating cystoscope. For the cure of anomalous insertions of the ureter into the rectum, vagina, vulva, or seminal vesicle, an implantation of the ureter into the bladder must be made. The methods by which this is to be accomplished will be considered under Ureteral Operations (p. 265).

Movable and Floating Kidney.—The normal kidney makes a limited excursion, like the spleen, in a vertical direction, with the movements of the diaphragm. In deep inspiration the descent is about one inch. This is sufficient to permit the palpation of the kidney in part on the right side in about 60 per cent. of all subjects, and the left in about 8 per cent. of men and 30 per cent. of women. In girls of slender build the respiratory movements of the kidney can be most easily demonstrated. When the whole kidney can be palpated, the condition must be considered pathologic. The frequency of abnormal renal mobility is considerable. According to Küster, it occurs once in two hundred and seven men, in women once in twenty-two. Autopsy records by Epstein and Newman show only sixteen cases in over fourteen thousand autopsies. These are not as reliable as examinations made in the living, for it is evident that unless the mobility be especially looked for or extreme, it will not be observed at autopsy. In his latest article E. Hahn, who in 1881 established its surgical treatment, observes that in one hundred women he found the kidney movable in 5.5 per cent. In fifty children, equally

divided as to sex, he found but one movable kidney in a girl of eight. In one hundred men he observed mobility of the right kidney in two. Morris has had ninety-eight operations for movable kidney, with only ten on men.

The right kidney is involved about fifteen times as often as the left. According to Landau, both kidneys are involved in about 5 per cent. of all cases. This accords with the experience of most operators, although Edebohls in one hundred and eighty-six patients made a bilateral operation in seventy-four.

A distinction was formerly made on an anatomic basis between the movable and floating kidney. The presence of a distinct mesonephron was the essential of the floating kidney. In reality a true mesonephron can belong only to the congenital type of dystopia and is very rare. As a proof of its existence, anomalies of the renal vessels, particularly in regard to their origin, must be offered. Therefore it is proper that a clinical meaning should be given to the terms movable and floating to indicate the degree of renal displacement. Excursions of the movable kidney, however extensive in the direction of the long body axis, are altogether behind the peritoneum. The floating kidney, on the contrary, moves freely forward toward the anterior abdominal wall, though rarely touching it. It therefore may become an intra-abdominal organ, like the cecum. The movable kidney is very much more common than the floating, of which it is but an earlier stage. Between the extremes all degrees of displacement are encountered. Glénard describes four degrees: the first, in which the lower renal pole can be felt on inspiration alone; the second, that in which the greater portion of the kidney can be felt; the third, that in which on deep inspiration the whole kidney can be felt; and fourth, that in which the kidney as a whole can be felt regardless of the position of the diaphragm.

Etiology.—Although movable or wandering kidney is almost always acquired, there is a congenital predisposition to it. In women the paravertebral niches in which the kidneys are placed are, according to Volkow and Delitzin, more cylindric than in men and shallower and open below. Stiller demonstrated in many of his cases an abnormal mobility of the tenth rib, depending perhaps upon defective attachment of its tip to the rib above. Israel has confirmed this observation, and in two of his cases the writer has made the same observation. Albarran designates movable kidney as a stigma of degeneracy.

The most important factor in keeping the kidney in place is the intra-abdominal pressure. This is maintained by an intact abdominal wall. Any decrease of its supporting strength renders less secure the position of the abdominal viscera. Volkow and Delitzin have shown on the cadaver that the division of the abdominal wall causes the kidneys to sink to a lower position. Relaxation of the abdominal wall or of the floor of the female pelvis, as would occur after repeated pregnancies, is the most common cause of movable kidney. Therefore the disease is oftenest encountered in multiparæ between the twenty-fifth and fortieth year. On the other hand, child-bearing is far from being the only cause of

wandering kidney. The condition is often found in nulliparous women. Harris fixes the proportion at 40 per cent. Relaxation of the retroperitoneal fascia by absorption of its fat accounts for the not infrequent appearance of the condition after acute wasting diseases. Trauma, I believe, is often the direct cause of renal mobility. In three cases in the persons of girls under twenty, the writer has known the condition to be observed soon after a fall from a horse in one case, and in two after a playful scuffle. In none of them were there evidences of injury to the kidney itself. Scoliosis, by changing the form of the pararenal pocket, may be a direct cause of movable kidney. An enlargement of the kidney may, by reason of its weight, cause abnormal mobility. It is not positively established that an ill-fitting corset in women or the use of a loin strap in men is the cause of movable kidney. Quite often movable kidney is only a part of a general enteroptosis. In a number of cases of the latter, observed for a long period by me, the kidney was the first organ displaced. In a secondary way by traction on the duodenum and colon the loosening of the intra-abdominal viscera was seen to follow in a secondary manner. In exceptional cases nephroptosis causes a chronic inflammation of the appendix, either by obstructing its venous circulation or by causing a kink within it, or, as seems to me the chief reason, by giving rise to chronic and obstinate constipation. The latter, I believe, is often a primal factor in causing renal mobility. Traction of an overweighted cecum and colon, by inducing mobility in them, must easily influence the fixed position of the kidney. That the combined condition of nephroptosis and chronic appendicitis occurs in over 3 per cent. of women, as maintained by Edebohls, has not been the experience of most observers.

The preponderance of the condition on the right side has been charged to the naturally lower position and the proximity of the right lobe of the liver. A number of observers have corroborated the researches of Volkow and Delitzin showing that the right kidney niche is broader, shallower, and more open below than the left one. Landau holds the unsupported condition and greater length of the right kidney as compared with the left responsible for the preponderance of right displacements.

Symptoms and Diagnosis.—In a very large proportion of cases movable kidney does not cause any symptoms. The degree of mobility does not determine their severity. It is often detected accidentally and may thereafter, in nervous women, give rise to symptoms. In other cases severe accesses of pain, gastric disturbances, and neuroses make life miserable. The sensation most frequently experienced is that of something wrong or loose on one side of the abdomen. There is often a sense of weight and dragging pain, which predisposes to mental depression. The stomach participates very largely in the subjective symptoms. There is almost always anorexia, associated at times with vomiting and tachycardia, and jaundice is not rare. They result from pressure or traction on the duodenum, which in time may lead to gastrectasia. Disturbances of the urinary secretion are, as a rule, absent, although the pains often follow the course of the ureter and simulate that of a renal calculus. Pain in the labia, the testicle, or the thigh is common.

Sudden alterations in the relations of the vascular, nervous, or excretory apparatus of a floating kidney may cause alarming crises, with all symptoms of peritoneal shock. They usually follow severe exertions and are followed by sharp pain, vomiting, and tympany. During these crises the kidney is exquisitely tender and may be markedly enlarged by temporary hydronephrosis. With the close of the crises polyuria and hematuria are often observed. Usually the kidney "rights" its position, and the violent symptoms quickly subside. These crises were first described in 1864 by Dietl, who attributed them to strangulation of the kidney.

In a large proportion of cases, chiefly in the upper social strata, the nervous symptoms predominate. They are of the entire gamut of neuropathy, and in course of time bring about a condition of inveterate invalidism. An inherited neurotic tendency is often found to be the basal factor in this condition, as in that of the more extensive enteroptoses.

The **diagnosis** is, as a rule, easily made by bimanual palpation, which reveals an abnormal, mobile, and dislocated kidney, recognized by its form and size. When the condition is suspected and the kidney for the time being is in a normal position, it can easily be displaced and demonstrated as mobile by postural changes. A corset liver, tumors of the hepatic flexure, a pendulous gall-bladder, or a pyloric carcinoma may be confounded with movable kidney; but in none of these conditions can the tumor mass be made to disappear for any length of time. As compared with a movable and distended gall-bladder, the wandering kidney has a wider range of movement. The mobile gall-bladder can only move in the arc of a circle beneath the edge of the liver. Other clinical phenomena must aid in the diagnosis.

In acute renal crises, particularly if renal ptosis is unsuspected, the diagnosis may be very difficult. Careful analysis of the concomitant urinary symptoms, of the nature of the pain, with the detection of a painful and perhaps distended kidney, usually suffices to clear up any existing doubt.

The prognosis of movable kidney is good as to life. The condition may continue for years. Spontaneous cures have been observed mostly in women who have taken on flesh rapidly. Pregnancy has also been known to be followed by disappearance of symptoms. In most cases an anatomic cure cannot be looked for without operation, although the nervous symptoms which are in many instances sufficient to establish a condition of chronic invalidism may be favorably influenced by internal treatment that probably is only of suggestive value.

Treatment.—This resolves itself into the palliative and curative. In the majority of cases the former alone suffices. A statement made to the patient that the floating body is not a tumor often relieves all anxiety. To relieve the actual discomforts, trial should first be made of an abdominal supporting bandage. To be of service this must surround the abdomen from the pelvis to the thorax to substitute the lost intra-abdominal pressure, the radical basis factor of movable kidney. A pelvic band with lateral steel uprights, reaching half-way to the axilla on each side, gives firmness to the apparatus. It should be so arranged that

pressure is made in an upward direction. Renal trusses with large pads to fix the kidney are rarely of service and often harmful. In conjunction with this orthopedic treatment in recent cases, a rest cure with hyperfeeding is often of the greatest value. This is particularly true in emaciated subjects, in those in whom the nervous symptoms predominate, and in whom a movable kidney is but a part of a general visceral descent. It is for this reason that many operators of wide experience, like Israel and Tuffier, have restricted the indications for operation. Tuffier, for example, operated on sixty-four wandering kidneys between 1888 to 1894. In the following three years he operated on only eight. Larrabee bases a similar opinion on a clinical study of one hundred and twelve cases.

Operative Treatment.—Until E. Hahn in 1881 first fixed a movable kidney by an open operation, nephrectomy was practised in severe cases. At present extirpation of the kidney for this condition must be reserved for extreme cases in which repeated efforts at fixation have failed to be of service. According to Hahn, of forty-two nephrectomies for movable kidney, six died of uremia and fourteen of sepsis or peritonitis. These statistics, of course, for the most part are of a period preceding the modern advanced methods of wound treatment.

The operation of fixing the kidney was called nephrorrhaphy by Hahn and nephropexy by LeDentu in 1889. It is positively indicated in all cases in which renal crises occur. Ureteral catheterization may be used to determine the degree of urinary retention. Intermittent hydronephrosis, hematuria, severe pain, and beginning gastroptosis indicate operation. In general enteroptosis the fixation of the kidney alone is followed by not more than temporary benefit. Although, as a rule, in cases presenting a preponderance of nervous symptoms kidney fixation is not of permanent benefit, the writer has seen a number of instances in which permanent good results were obtained. The operative mortality of nephropexy is very low. In 1895 Delboie collected three hundred and sixty-three cases with five deaths. In eight hundred and forty-six operations collected by Edebohls the mortality was 1.65 per cent. In view of this low death-rate from the operation it seems certain that whenever the symptoms are severe or the condition itself is a source of anxiety, kidney fixation should be done. That a permanent cure of all the symptoms follows in a large proportion of cases cannot be questioned. In fully 65 per cent. of all cases permanent cures are achieved. Albarran, who places the sutures through the kidney, has obtained a permanent recovery in 78 per cent. of his cases. In about 20 per cent. of all cases there is a partial failure, often due to recurrence of the condition. Second operations have repeatedly been performed with success.

PERINEPHRITIS; PARANEPHRITIS.

The connective-tissue covering of the kidney, including the fat layer and the peritoneum in front, reacts in various ways to inflammations of the kidney proper. The peritoneum and the capsula propria are never the seat of primary disease or of suppuration; but in a way, and always

PLATE II.

Renal Lipomatosis—from Stone (Cincinnati Hospital Museum).

secondary to disease of the kidney, are capable of enormous thickening. The fat covering, on the other hand, is very frequently infected from sources foreign to the kidney. Technically, a differentiation of the various conditions should demand an indicative nomenclature. No little confusion has resulted from efforts in this direction. Rayer reserved the term "perinephritis" for inflammations of the fat capsule. French, English, and American writers have continued the use of this term in the same sense. Küster applied the name to inflammations in front of the kidney and reserved the term "paranephritis" for the suppurative processes in the retrorenal fat. Israel would designate the thickenings of the fibrous capsule as perinephric, and inflammations within the fat capsule as epinephric. Unfortunately for this nomenclature there is often shown a successive involvement of all the circumrenal connective-tissue layers, and the difficulties of clinical and even anatomic differentiation at operation or autopsy may then be insurmountable. For these reasons the term "perinephritis" will be used in its wider limitation to indicate inflammations of the fibrous, cellular, and fat tissue surrounding the kidney.

With this acceptation of the term, three well-marked varieties of perinephritis exist. They are: first, the fibrous or sclerotic; second, the lipomatous; and third, the suppurative. The fibrous or sclerotic type involves the fibrous capsule and the fat layers immediately surrounding it. It occurs as a result of long-standing irritations and inflammations of the kidney such as follow stone, tuberculosis, and pyonephrosis. The adhesions in these cases are of great significance if nephrectomy must be done. The sclerosis extends into the hilum of the kidney, thereby making very difficult the separation of its structures before tying them off. In some cases the fibrosis, doubtless by gradual compression of the renal vessels, induces atrophy of the kidney.

The lipomatous variety results from a large increase of fat tissue of the capsula adiposa and involving the kidney proper through extension from the hilum. In extreme cases of this form the kidney appears as an irregular fat mass (Plate II) surrounded by a very dense fibrous capsule. The resemblance to the normal kidney may be lost, the mass looking like a lipoma. In the most advanced cases the greatly thickened fibrous capsule is filled by a fat mass in the center of which is an irregular cavity, the last vestige of the pelvis. I have recently met with two cases of this character: one discovered by autopsy as the result of chronic nephrolithiasis, the other by operation. In these cases the disease followed a long-standing pyelitis, probably of calculous origin. The mass in the one case was removed to relieve an embarrassing fistula. Although it weighed two pounds, the vessels were very small. Between the fibrosis and the lipomatosis there is no sharp dividing-line. It is more than probable that the fibrosis extending into the hilum may induce fat infiltration. Except when a fistula occurs, the lipomatous kidney is not to be made the subject of operation, although it may be impossible to recognize the condition beforehand.

Suppurating Perinephritis (Perinephritic Abscess).—Suppurations within the perirenal fat are for the most part due to suppurative

disease within the kidney resulting from calculous pyelitis, tuberculosis, or metastatic abscess. The genesis of perinephric suppuration in these cases is plain. Suppurations may extend also into the perirenal fat layer from infections of the appendix, of the pelvic viscera in women, and even from the prevesical and periprostatic connective-tissue spaces. Abscesses of the liver, of the gall-bladder, of the sheath of the psoas, and ulcerations of the duodenum may, through the lymph-channels, be the cause of perinephric abscess. In very rare cases extension downward of an empyema has been the cause. Trauma is a common cause of this condition, with or without recognizable injury to the kidney. Stab and gunshot wounds may produce it by direct infection. In a metastatic way the disease occurs after typhoid, measles, and influenza. Hematomata after contusions form very excellent foci for germ propagation. Whether this comes from the blood, from minute cortical tears or contusions, or from migration through the hollow viscera, it is difficult in the individual case to decide. Peripheral suppurations, like furuncles and felons, have recently been found to be precursors of perinephric suppurations. Jordon and Albrecht have reported a number of such cases.

The method of invasion of the retrorenal fat layer may be primary or hematogenous, *i. e.*, without involvement of the kidney, and secondary to disease of that or some other contiguous organ. It is customary to pronounce the case primary only when the urinalysis is negative. But circumscribed cortical contusions and abscesses do not of necessity make themselves manifest through the urine. The lymphatic and to a larger extent the vascular systems of the kidney and its coverings are continuous. Minute metastases and tears in the cortical layer are doubtless often the precursors of seemingly primary perinephric abscesses of metastatic or traumatic origin. As more careful analyses are made, the relative frequency of primary perinephritis diminishes. I have operated on one case following gonorrhea and two following typhoid. In each of these the pyelitis preceded the abscess formation, although in none of them could any gross connection with the kidney be demonstrated at the operation. In another case a phlegmonous perinephric cellulitis developed in a diabetic. The kidney was found intact at the autopsy. In forty-three cases operated upon by Israel, he found the kidney involved in thirty-four. In six cases there was a history of gonorrhea and in only three could the cause not be found. In twenty-one of the cases the abscess was consecutive to stone, pyelitis, and tuberculosis. Most cases occur in males. Of two hundred and eight cases collected by Küster, one hundred and forty occurred in males. Occasionally the disease is bilateral.

Symptomatology.—The sclerotic and lipomatous forms give no symptoms independent of the pre-existing disease of the kidney. The symptoms of the phlegmonous vary according to whether the disease is primary or secondary. In the latter conditions the symptoms belonging to the primary disease precede the invasion of the perirenal capsule. Given the history of stone, tuberculosis, pyelitis, or of tuberculosis of

the spine, empyema, or pelvic infection, the beginning of the perinephritis is evidenced by localized pain and tenderness in the loin and by more or less grave systemic febrile disturbances. In seemingly primary cases following trauma or in the metastatic from furunculosis or one of the acute infectious diseases, the disease may be ushered in with a chill, followed by a rise of temperature and the rapid development of the local symptoms above named. The course of the temperature and the blood-count are characteristic of suppurative processes elsewhere. Pain, which is often the initial local symptom, is, as a rule, much severer than in intrarenal suppurations. Reflected pains in the thigh and scrotum are very common, and by reason of irritation or actual involvement of the psoas muscle the thigh assumes a position of flexion. Extension of the thigh, if possible, is very painful. Pain reflected to the knee is sometimes complained of, and Gibney has called attention to the danger, on account of these two symptoms, of mistaking the perinephritis, before an external swelling is observed, for hip disease. The spine is, as a rule, fixed and sometimes deviates from the affected side. The progress of the symptoms is, as a rule, rapid, so that within the course of ten days or two weeks a well-marked fluctuation is felt in the loin. In other cases the progress is less rapid and the symptomatology proportionately more obscure. The rapidity with which the swelling is recognized depends upon the situation of the abscess. In most instances it is distinctly retrorenal and extends toward the lower pole of the kidney. It is in these cases that the thigh symptoms are oftenest seen, and the swelling in the region of the kidney is soon apparent. When the abscess forms nearer the upper pole the symptoms simulate those of subphrenic abscess, in that limitation of diaphragmatic movements on that side is well marked. The higher up the original focus of suppuration is, the more likely are severer symptoms on the part of the alimentary canal to arise. Persistent vomiting, jaundice, and obstipation may all belong to the symptomatology of perinephric abscess.

The important diagnostic feature of this condition is the local swelling. This is often preceded by a marked and painful resistance which is revealed by bimanual palpation. Three cardinal local features belong to perinephric infiltration: First, the swelling is behind the kidney, and even when very large does not approach the anterior abdominal wall. Second, the swelling is diffuse and without the well-marked limitations which belong to enlargement of the kidney proper. Third, the swelling is uninfluenced by respiration. As the disease progresses in most cases, if left untreated, an inflammatory cutaneous edema makes the diagnosis certain.

Aspiration can always be resorted to as a means of diagnosis, although the abscess may be so small that even an incision may fail to reveal it. In other and usually neglected cases the abscess may be very large, extending from the diaphragm to the groin and often beyond the midline. As a rule, the pus contained within the abscess is quite free from odor, whereas in others it is distinctly fecal. In the lumbar abscess of appendiceal origin the abscess not infrequently contains gas.

The organisms which have been found in the pus evacuated from the perinephric abscess are the ordinary pyogenic cocci, the colon bacillus, and the diplococcus.

Prognosis.—Suppurative perinephritis, according to Küster, has a mortality of 34 per cent. The prognosis depends upon the time of surgical treatment, for a timely incision renders most cases capable of recovery. If left to itself, a perinephric abscess in most instances points at and breaks through the loin. Rapid defervescence often follows. Unfortunately, if this eventuates it may not be until extensive burrowing has occurred toward the diaphragm or the groin. The abscess may empty itself through the pelvis of the kidney, through the intestine, or, like abscesses of the liver, through the bronchus. Fatal peritonitis may result from a rupture, but this termination is rare. Where an operation has been long delayed, recovery is tedious, through the difficulty of maintaining sufficient drainage. Discharging fistulas are very common. In abscess secondary to disease of the kidney a permanent renal fistula may remain until the primary condition is relieved.

Treatment.—This may be summed up in advocating an incision as soon as symptoms indicate the presence of pus. Aspiration may be resorted to for diagnostic purposes to guide the direction which the operation is to take. It is within the experience of most surgeons that small abscesses not discovered at the operation will empty themselves through the wound within a day or two.

The best incision is the oblique one, through which the skin and muscle layers are divided until the retrorenal fascia is reached. It is best to open the abscess with a small incision, gradually enlarging it with scissors or probe-pointed knife guided by the finger. A very careful examination of the abscess cavity is essential to determine the presence of secondary pockets which may require a separate incision in the inguinal or gluteal region. As a rule, an effort should be made to expose the kidney to either view or touch, care being taken not to wound the fibrous capsule, unless there is evidence of suppuration within. A stone will sometimes be found in the abscess. The treatment required for the primary condition of the kidney may be carried out at the time the perirenal abscess is opened, although in most cases the condition of the patient with a perinephric abscess is such that it is the part of wisdom to defer the operation on the kidney until he has been given an opportunity to recuperate. Primary nephrectomy in the febrile state of the patient should not be done.

INJURIES OF THE KIDNEY.

Although wounds of the kidney are comparatively rare, they were fully recognized and described by writers of antiquity. The opportunities of any individual for extensive observation are limited. Küster, in seven thousand seven hundred and forty-one injuries at the clinics of Basel and Berlin, could tabulate only ten cases, or a little more than one in a thousand. Of these ten, only one was an open wound. Of two

thousand six hundred and ten autopsies there were thirteen injuries to the kidney, with only one of a penetrating nature. Israel records, notwithstanding his large experience of renal surgery, only one operative case. During the war of the American Rebellion there were, altogether, eighty-five gunshot wounds of the kidney, of which twenty-six recovered. Statistics of wounds have been made by Adler, Maas, Keen, and Küster. The analysis of Keen's one hundred and fifty-five cases shows nineteen gunshot wounds, eight penetrating wounds, one hundred and eighteen subparietal ruptures, two partial nephrectomies for rupture, six traumatic hydronephroses, and two ruptured ureters (pelvis).

Injuries of the kidney may be divided into two groups: First, subparietal injuries; second, penetrating wounds, with the subdivisions of incised, punctured, and gunshot.

Subparietal Injuries.—These occur in men very much oftener than in women. Of two hundred and ninety-nine cases of Küster, two hundred and eighty-one occurred in men. According to this authority, an injury in the loin tends to produce a contusion or often a rupture; whereas in women, mobility of the kidney is more likely to result. It seems more probable, however, that the proportion given by Küster is really explained by the greater frequency with which men are injured. Injury of the kidney is, as a rule, the result of direct violence. In rare instances both kidneys are hurt. Violence or falls from considerable heights without direct injury may produce rupture of the kidney. The manner of production of the injury varies in different cases, and where the injury involves the lower ribs, there can be but little question but that the kidney is caught and crushed between the vertebral column and the ribs. Küster has shown by experiment that a common cause of rupture is the hydraulic pressure acting through the full vessels and pelvis, causing the kidney to burst. Experimental work bears out the theory of the effectiveness of hydraulic pressure in the production of ruptured kidney. It cannot explain the cases in which the kidney is torn across near its pedicle nor the wounds that involve the cortex and fibrous capsule only.

Pathology.—Injuries of the kidney and its coverings vary in degree from simple contusions to extensive ruptures and complete pulpifying. The contusions may involve only the cortical portion with an intact capsule, or a tear may extend far into the substance of the kidney, involving the pelvis and the larger branches of the renal vessels. Injuries of the kidney and its connections may be divided according to degree as follows:

First, tears of the capsule, with or without injury to the kidney.

Second, contusions of the cortex with tear of the fibrous capsule, but without injury to the pelvis. In these cases the perirenal fat is the seat of an extensive hematoma. The peritoneum may be torn with the escape of blood into the abdomen. This is more likely to occur in children because of the absence in them of the perirenal fat. De Quervain found the peritoneum torn in seventeen out of two hundred and fifty-four cases of subparietal injury of the kidney.

The lacerations are oftener found on the anterior surface of the kidney,

and have either a horizontal direction or run radially from the hilum. It seems to me that the more frequent occurrence of injury to the front of the kidney may be explained by the doubling up of the gland, as the force is generally applied from behind, and that with the increased hydraulic pressure the kidney gives way at its least supported part, namely, in front.

Third, extensive single and multiple lacerations extending into the pelvis may completely separate portions of the kidney from each other. The tears are in the direction of the interlobular lines of the embryonic kidney. They have been compared somewhat aptly to the cracking of wood in the direction of its fibers. Extensive tears associated with profuse hemorrhage into the perirenal tissues produce deep-seated hematomata in the lumbar region. These bleedings may extend along the spermatic veins toward the inguinal region, into the scrotum and the base of the penis. The bladder is often found filled with clotted blood. When the peritoneum is torn, there is no pressure to resist extravasation, and the hemorrhage may be rapidly fatal. In a case of pistol-shot injury of the right kidney near the hilum, the hemorrhage into the abdomen was fatal before the kidney could be removed. In extreme degrees at autopsy or operation the kidney may be found pulpified. When the force of the trauma has been expended near the hilum, the kidney itself may be but little injured, although its vessels, the pelvis, or the ureter may have been entirely torn across.

FIG. 122.—SUBPARIETAL RUPTURE OF KIDNEY.

Injuries of the kidney are, of course, often complicated by other lesions, such as fractures of the ribs, of the spine, and rupture to other abdominal viscera. Thus in twelve out of seventeen deaths from kidney injury collected by Keen, such additional injuries were found.

Symptoms.—These may be divided into general and local; primary and secondary. The primary general symptoms of injury to the kidney are those common to severe injuries in general. They are the symptoms of shock and of severe hemorrhage. But often in extensive ruptures shock may be long delayed or entirely absent. Patients have walked long distances and continued work for some time after sustaining severe injuries of the kidney. The patient from whom the kidney shown in Fig. 122 was removed continued at work for five hours before experiencing any marked weakness. I recently saw a woman of seventy-five with an injured kidney. Rather profuse hematuria was present for a

week before there was any acceleration of the pulse-rate. She recovered without operation.

The primary local symptoms are pain and tenderness, swelling, and hematuria. The pain is generally deep-seated and dull, although from the expulsion of blood-clots through the ureter it often becomes paroxysmal and very acute. As retrorenal extravasation ensues it becomes radiating and diffuse. Postural changes and deep inspiration increase it. The abdominal muscles are often rigid, and the patient assumes the posture of subjects with perinephric abscess. Painless cases have been demonstrated by autopsy, but it is difficult to conceive how bimanual palpation could fail to reveal tenderness in even slight renal tears.

Through bimanual palpation the second primary cardinal symptom, the swelling, is made manifest. Generally, this is ill-defined and diffuse and involves the entire costo-iliac interval. It is produced by the infiltration of the perirenal and circumrenal tissues with blood and urine. If the examination reveals a well-defined swelling, rounded and perhaps movable, it shows the absence of extravasation and the retention of urine within the kidney capsule proper. It is a condition of hematohydronephrosis. The ecchymosis often seen in the lumbar region in rupture of the kidney, when primary, is due to superficial contusions of the soft parts incident to the injury. In most cases ecchymoses appear late, if at all.

Hematuria is the most constant primary symptom of rupture of the kidney. It occurred in sixty-five out of seventy-one cases tabulated by Maas. In twenty-six cases of Morris it was present in eighteen. It comes on, as a rule, soon after the accident and varies in intensity and duration. In contusions of mild degree the urine is smoky and shows little tendency to clotting. In more extensive tears clotting is quite common, either in the ureter or in the bladder. In severe hemorrhages from the torn kidney the bladder may become filled with clots, which can only be evacuated through a large catheter and by suction. Ureteral colics are of common occurrence in these hematurias and occasionally the blocking of the ureter gives rise to the acute condition of hydrohematonephrosis already alluded to. On the other hand, injury of the cortex alone may not make itself manifest through blood in the urine. In very severe lacerations involving the pelvis, hematuria may also be absent through blocking or displacement of the ureter. Thrombosis of the renal vessels and stricture of the ureter antedating the trauma may also explain the absence of hematuria.

Hematuria may disappear in twenty-four hours or it may continue for as many days. In injuries of moderate degree it gradually disappears in from three to four days. Albuminuria sometimes continues for many weeks after the blood has disappeared. Tuffier has described a tardy hematuria which may come on after the lapse of a week or more, and can be explained by the escape of a perirenal hematoma through some channel which has reopened into the kidney and pelvis.

The secondary general and local symptoms of rupture of the kidney are due to the changes which take place in the kidney, and particularly

in the circumrenal and connective tissue, by reason of the infective or reactional processes following the exudation of blood and urine. They are the symptoms of either rapidly developing perinephritis or of an acute peritonitis. An aneurism may develop likewise in the main renal artery or one of its branches. The condition of hydronephrosis is sometimes directly attributable to preceding trauma. The injury of the kidney itself may lead to localized infarcts with subsequent abscess formation, or to a non-suppurative localized inflammation which may result in a unilateral nephritis of chronic character. The symptomatology of all these secondary conditions will vary according to the nature of each and will be considered in its proper place.

As a result of rupture of the kidney, anuria has often been noted even in cases where the injury was unilateral and of moderate degree.

Prognosis.—The dangers of rupture of the kidney are either primary or secondary. The chief primary danger is that of hemorrhage. If death occurs later, it is from infection, either from cystitis through catheter infection, from gonorrhea, from infection through weakened intestine, or one of hematogenous character.

In uncomplicated cases the prognosis varies with the degree of injury. Of one hundred and eight cases of Grawitz, fifty-eight recovered. In the fatal cases there were usually injuries of other organs. In fourteen a primary hemorrhage caused death, in seven suppurations of the kidney, and in three anuria. Of Küster's three hundred and six cases, two hundred and twenty-two were uncomplicated, with a mortality of 31 per cent. The eighty-four cases complicated with other injuries showed a mortality of 92 per cent. Of sixty-seven fatal cases, ten died within twenty-four hours, thirteen within six days, and twenty-one within three weeks. Thirty of the cases died from hemorrhage.

Treatment.—This may be properly divided into the primary and secondary. As soon as the diagnosis is made the question of immediate operative interference must be considered. Where the symptoms—such as slight hematuria, the presence of only a limited swelling in the lumbar region, and the absence of the symptoms of general shock—indicate limited contusion, rest in bed, strapping of the part, and anodynes to relieve pain are all that will be required. It is questionable whether any internal medication or the hypodermic use of ergotin, or even adrenalin, can influence the bleeding. Rest in bed should be maintained for at least three weeks to prevent recurrence of bleeding and the tendency to nephroptosis. The blood-pressure should be kept as low as possible by low diet. When the hematuria is severe, and even more so when a lumbar hematoma is growing, and particularly when there are evidences of intraperitoneal bleeding, the indications are for immediate operation. Not only the hematuria, therefore, but the concealed hemorrhages around the kidney and within the peritoneum indicate immediate operation. In most cases the idea of the operation is, in the first place, exploratory. Only after the kidney has been exposed and the degree of injury ascertained can the proper operative therapy be instituted. It is advisable to resort to early operation when the hematuria, though

not profuse, is continuous or recurrent. It is better here to risk an unnecessary operation than to wait until the patient is so reduced that an operation must be undertaken under most unfavorable circumstances.

When the exploration shows only a partly lacerated kidney with the margins of the tear in a position to be approximated, sutures of catgut may be used to close the gap. Bleeding vessels that are found near the hilum must be tied. If parts of the kidney are nearly severed and much contused, they should be removed by partial nephrectomy. Morris refers to four cases of this nature. This may be followed by suture. In all of these conditions gauze packing is indicated. When the renal pelvis is found blocked with clot, a pelvic fistula should be established after the clot is removed by incision.

When the kidney is found hopelessly destroyed or it has been found necessary to tie large branches of the renal artery, immediate removal of the kidney is indicated. Unfortunately, this must often be done before the presence of a second kidney can be established. It is true that Bobroff showed that tying the renal vessels experimentally does not necessarily cause necrosis of the kidney. Nevertheless, in the injured state of the organ the cutting off of the blood-supply would almost inevitably be followed by its sloughing. If the operation shows that the peritoneum has been opened, the abdominal cavity must be explored either through the wound in the loin or by median section. In cases where the injury to the kidney is but part of the damage done to the abdominal viscera, a large median incision is to be preferred to the lumbar, because it affords a better opportunity of dealing with them. In five cases laparotomy followed by nephrectomy, ligation of the vessels, or gauze packing has been resorted to by Kehr, Tuffier, Souligoux, Petroff, and De Quervain. Two cases died. One of those recovering had a transperitoneal fistula, which made a secondary nephrectomy imperative.

Collective statistics show that early exploration gives the best results and should be practised except in mild cases of contusion. Delbet collected three hundred and nineteen cases, of which two hundred and twenty-five were treated expectantly, with one hundred and three deaths. Many of these fatal cases were in such a condition as not to warrant an operation. In fifty cases the kidney was treated by suture, packing, or partial resection, with two deaths. In forty-four primary or secondary nephrectomy was followed by a mortality of 25 per cent. Watson has collected the largest tables. Of two hundred and seventy-three cases treated expectantly, eighty-one died; ninety-nine were treated by a conservative operation, with seven deaths. In one hundred and fifteen nephrectomy was performed; and of these, twenty-five died.

When it is considered that the majority of cases, although not all, expectantly treated, are those of slighter injury, and that those operated on are *a priori* the graver ones, and that many operations are long delayed, there can be no question of the life-saving influence of early operation for rupture of the kidney. Keen has shown that secondary nephrectomy for trauma is twice as fatal as primary.

Wounds.—(*a*) Incised or punctured. (*b*) Gunshot wounds.

Incised or Punctured Wounds.—Wounds of this character, particularly stab and incised wounds, are very rare. Gunshot wounds are of more frequent occurrence. According to Wagner, there have been recorded only sixty cases of the former and two hundred of the latter. Wounds of the kidney other than gunshot wounds have usually been inflicted by knives, scissors, scythes, or similar weapons. Other organs are not usually involved, for reasons that are evident. Keen refers to a case in which a pitchfork entered the anus, tore the rectum, and lacerated the upper third of the left kidney. These wounds, like subcutaneous ruptures, may involve different parts of the kidney. In very rare cases of incised wound prolapse of the kidney is present. Pilcher refers to two cases of this kind where nephrectomy was followed by a good result. If seen early, conservative treatment of the kidney is indicated. The symptoms do not differ in any marked way from those of subcutaneous injury. If the pelvis has been opened, a renal fistula will speedily develop. Without this characteristic symptom of wound of the kidney, the diagnosis rests, with sufficient certainty to warrant exploration, on the presence of hematuria and regional pain, even if there are no evidences of extravasation of blood or of urine in the loin. Since kidney wounds heal promptly if aseptic or if they are made so, an effort must be made to close the wound by suturing. In some cases a single or double purse-string suture may be utilized.

Gunshot Wounds.—Of these, Keen collected nineteen cases. They occur, of course, oftener in military practice. Eighty-five are recorded as having occurred in the Civil War and fifteen in the Franco-German War. Gunshot wounds of the kidney are, as a rule, associated, particularly in military practice, with lesions of other intra-abdominal organs, notably the stomach, liver, or intestine. In wounds entering anteriorly such a complication is almost inevitable. In wounds from the side the kidney alone may be injured. The wounds may involve the body of the kidney, the pelvis, or the ureter. Clean wounds of the body of the kidney, particularly near the border, present some radiation, but may not bleed much. Clotting soon occurs in the wound channel and the vessels become thrombosed. When the pelvis of the ureter or its upper portion is injured without being completely severed, extravasation about the kidney and hematuria will manifest themselves. When the primary or even larger branches are injured, very severe hemorrhages may occur within the peritoneum, as in a case already alluded to, or behind the kidney. Secondary changes, usually the result of infection in the kidney. and surrounding tissues, may occur, as after traumata of the kidney from other causes. Secondary hemorrhage occurs oftener after gunshot than after other injuries of the kidney. The symptoms are those common to subparietal injuries besides those dependent upon the presence of an external wound and upon injury to other organs. Foreign bodies, like articles of clothing, have repeatedly been found in the kidney, and may become the nucleus of a stone or may be passed into the bladder. The prognosis of gunshot wounds has been improved with the general improvement of surgical cases. During the American Civil War the mortality

was 69 per cent. In the Franco-Prussian War it was 53 per cent. According to Küster, fifty cases in civil life, mostly pistol wounds, show a mortality of 26 per cent.

Treatment.—Gunshot wounds of the kidney in civil practice almost always demand exploration on account of the concomitant injuries. If there are no signs of such injuries, conservatism may be practised. If the direction of the bullet wound would indicate that only the kidney is injured, an expectant treatment may be followed unless profuse bleeding demands exploration. Only in this case is a lumbar incision to be selected. In other cases the incision should be made in the midline, as affording the best means for treating conditions as they are found. Nephrectomy for severe lacerations and profuse hemorrhage may be performed transperitoneally. In milder cases the treatment consists of interrupted or purse-string suture and drainage through an incision in the loin. In exposing the kidney through the abdomen care must be taken not to injure the colonic vessels, lest gangrene ensue. In the first nephrectomy ever performed for gunshot wound (Keen), the patient died after two weeks from intestinal gangrene caused by an injury by the bullet before it struck the kidney.

DISEASES OF THE KIDNEY.

Hydronephrosis.—Although distention of the pelvis of the kidney with the interesting feature of intermission was already described by Tulpius, it remained for Rayer to give the name "hydronephrosis" to the condition of retention from obstruction at some point below. For retention within the renal pelvis, infundibula, and calices, which is always the result of hydraulic pressure irrespective of the nature of the retained fluid, whether it is urine and pus or urine and blood, the term "sacciform kidney" (Sackniere) has been introduced by Küster and "nephrectasis" by Morris. The latter term expresses accurately, as does the term gastrectasia for the stomach, a dilatation of the pelvis of the kidney and its tributaries irrespective of cause. In so much it merits general adoption.

The effect on the kidney of obstruction to the outflow of urine varies according to the rapidity with which the obstruction is produced, whether it is complete or incomplete, permanent or temporary. Experimental research by Guyon, Robinson, and Bradford shows conclusively that partial obstruction gives rise to hydronephrosis, while complete obstruction supervening suddenly is followed by slight distention and atrophy of the kidney. Bradford, experimenting upon dogs, found that after complete obstruction of the ureter the kidney would regain its form, although it was very much smaller if the obstruction was removed in from ten to forty days. Sudden and complete obstruction inhibits excretion and diminishes relatively the proportion of urea and of the chlorids. Complete suppression does not occur in incomplete obstruction until late, if at all, so that unless the obstruction yields from time to time, enormous distention of the kidney ensues. The size of the hydronephrotic kidney varies, therefore, between moderate distention of the pelvis and retention cysts that equal in size large ovarian tumors. With the

increase of the internal pressure the papillæ are gradually flattened and the parenchyma becomes atrophic. The dilated calices appear as irregular cavities communicating with each other through the dilated pelvis, but separated from each other by septa, which, as the disease progresses, are absorbed, so that in long-standing cases a unilocular cyst is found, the walls of which are made up of a thin layer of atrophic kidney tissue.

Etiology.—The obstruction which causes hydronephrosis may be congenital or acquired. In the former there has been found a partial stenosis of the ureter, usually at its proximal end or in its intravesical portion. According to Englisch, it occurs in equal proportion at the two extremities. A valve formation may actually be formed in the ureter, or an anomalous high insertion of the latter into the renal pelvis may have the same effect. When, as occasionally occurs, there is a double pelvis or ureter, the hydronephrosis may be limited to a part of the kidney. Malpositions of the kidney, together with kinking or contortion of the kidney, may produce congenital hydronephrosis. An anomalous accessory renal artery given off from the aorta and crossing behind and distributed over the anterior portion of the lower pole may, with slight mobility of the kidney, give rise to hydronephrosis. Ekehorn has recently permanently relieved this condition by division of the offending branch between two ligatures.

Acquired hydronephrosis may find its cause in the kidney itself or in any portion of the urinary tract. Phimosis, strictures of the urethra, prostatic hypertrophy, and tumors of the bladder are potential causes of hydronephrosis. In all of these cases the disease is probably bilateral and associated with extensive dilatation of the ureters. A tumor or a stone in the pelvis of the kidney may produce renal distention. Obstruction within the ureter by a stone, scar formation, or sclerosing ureteritis is a frequent cause of hydronephrosis. Obstruction of the ureter from without, and particularly in women by pelvic tumors, frequently causes it. Morris found this cause present in one hundred and sixteen out of one hundred and forty-two cases. There were two cases of cancer of the ovary. In ninety-three the hydronephrosis was bilateral. By displacing the kidney scoliosis may produce renal retention.

Finally, movable kidney is, next to pelvic tumors, the most common cause of this condition. Renal mobility means an abnormal course for the ureter, particularly of its upper portion, which is less adherent to the peritoneum than are the lower segments. Kinking of the tube can, therefore, follow easily, and may lead to complete obstruction. With the return of the kidney to its normal position the hydronephrosis disappears. To this intermittent hydronephrosis L. Landau has directed attention. Terrier and Tuffier have demonstrated on animals this effect of movable kidney. As a rule, movable kidney, even with well-marked renal crises, is not associated with hydronephrosis. I encountered it twice in eighteen operations. In a certain proportion of cases the mobility of the kidney may be secondary to its distention. Bazy believes this to be the usual course. Israel has shown that in movable kidney a branch of the renal artery, by crossing the ureter, may cause its

compression and produce retention. Trauma occasionally is followed by hydronephrosis. Wagner states that only fifteen cases have been reported. The condition develops after traumatic strictures or from compression of the ureter by organized perirenal or peri-ureteral blood-clot.

A form of pseudohydronephrosis may result from injuries of the kidney followed by perirenal retention cysts. To distinguish this from a true hydronephrosis is always easy at the time of operation.

The whole or part of the kidney may participate in the distention. Total hydronephrosis is the common condition. Partial hydronephrosis is seen in tumors, in stones impacted in one or other infundibulum, or in cases of double ureter.

Pathology.— In the beginning of a total hydronephrosis the pelvis and its tributaries are first distended and the renal parenchyma, though somewhat thinned, appears like a helmet covering the pelvic pouch and forms the smaller part of the tumor. The papillæ are more or less flattened. When more extensive, the parenchyma and pelvic sac form a continuous cyst of rounded form, irregular surface, and multilocular. With the continuousness of the obstruction the cyst wall becomes attenuated, the interlobular septa become absorbed, and the final product of the condition is an unilocular cyst. In this cyst wall, according to Landau, vestiges of parenchyma of functional capacity are found except in extreme cases. Ayrer maintains the same view after examining four hundred and seventy-three reported cases, of which in only eleven was there a record of total disappearance of kidney tissue. In old-standing cases the cyst wall is noted for the firm adhesions which attach it to contiguous parts. The size of the cyst is at times enormous. In one case 36,000 c.c. of fluid were removed (Koenig). With the development of the cyst, neighboring organs are compressed or displaced and death ensues from pressure on the diaphragm.

FIG. 123.—HYDRONEPHROSIS.

The ureter always participates in the distention above the constriction. Often it is as large as the finger, and in exceptional cases it has been found as large as the small intestine. When valve formation due to high insertion of the ureter is the cause of the hydronephrosis, the ureter is almost invariably found in close relation with the anterior wall of the sac and near its median margin.

The contents of an aseptic hydronephrosis are, as a rule, limpid and clear, of low specific gravity, and in the beginning of uriniferous odor. As the atrophy of the parenchyma progresses in old-standing cases the likeness to urine gradually is lost. In many cases hemorrhage into the sac changes the appearance of the contents.

Symptoms and Prognosis.—The course of hydronephrosis varies even in the individual case according to the patency or the occlusion of the ureter. As long as the ureter is open from time to time the renal distention may diminish or disappear entirely, later to recur. In other cases drainage from the pelvis is continuous but insufficient. In them distention occurs notwithstanding the continued discharge of some urine into the bladder. For these the terms "intermittent" and "open" hydronephrosis may be used, whereas the term "closed" hydronephrosis is reserved for cases in which the obstruction is permanent. Hydronephrosis may for a long time run an aseptic course and not give rise to symptoms. In cases in which the disease is bilateral death generally ensues from uremia even before a well-marked tumor shows itself. With the excessive growth of the cyst from complete obstruction there arises the danger of rupture into the peritoneum or some contiguous organ. The chief danger lies in the possibility of infection and of general sepsis. If the infection is less virulent and the hydronephrosis an open one, the disease may be protracted. Rupture of a hydronephrosis from trauma has been recorded in nine cases by Oehne. Eight cases were operated upon. Of three transperitoneal nephrectomies, two died; of four lumbar, one died. One nephrectomy performed by the combined method was followed by death.

A small hydronephrosis may produce no symptoms. In diseases of the lower urinary tract, when uremic symptoms develop, examination may reveal an enlargement of the kidney. In other cases the appearance of a swelling in the region of the kidney, either oblong or round, with a fairly smooth surface and perhaps altogether painless, is the first indication of a hydronephrosis. In its earlier stages it is frequently possible to distinguish by palpation the firmer portions of the kidney parenchyma from the softer and fluctuating distended pelvis nearer the midline. In some cases, particularly those associated with movable kidney, ballottement is feasible. The percussion note of the tumor is flat. Below and within, the limit of the enlargement is shown by the tympanitic intestinal note. Fluctuation is demonstrable in proportion to the size of the cyst. In extreme distention the wave may be as distinct as that of an ascites or a unilocular ovarian cyst.

Pain, if present at all, may be of a dull aching character or decidedly paroxysmal. The latter symptom belongs particularly to the intermittent form.

The urine may be perfectly normal. It may vary remarkably in quantity. In some cases by pressure, as from an examination, the hydronephrotic cyst may in part be emptied. Sometimes in the intermittent type hematuria, often quite profuse, follows after a period of occlusion, as shown by renal colic. When pyuria occurs, it shows that the hydronephrosis has become infected.

The differential diagnosis is difficult only in rather extreme cases. It has most often been mistaken for an ovarian cyst and for encysted ascites. Enlargements of the gall-bladder have also been mistaken for hydronephrosis. Although differential diagnosis can in most cases be made by an aspiration and examination of the fluid, it is better to establish the diagnosis by an exploratory incision. Cystoscopic examination with ureteral catheterization, if need be, will almost to a certainty prevent an error of diagnosis.

Treatment.—Since Trendelenburg in 1886 reported the first plastic operation on the pelvis of the kidney for hydronephrosis, the tendency has been growing toward conservatism when the parenchyma of the gland is capable of good function. If, however, little kidney tissue is left, and if the retention tumor be very large or the obstruction cannot be relieved, nephrectomy must be done if the other kidney is normal. It ought rarely be primary. To determine between a conservative and radical procedure, the functional capacity of the distended kidney should be established. If the excretion is of low specific gravity and poor in urea, the conservatism of the kidney is not of sufficient importance to warrant repair operations. When a fistula remains after a nephrotomy, the functional capacity is, of course, easily determined. Catheterization of the ureter has been used to stretch a stricture and the catheter has in some cases been allowed to remain for a considerable length of time. Some good results have been achieved. If it can be determined that the hydronephrosis is secondary to some pelvic disease, this rather than the hydronephrosis must be made the object of operation. Aspiration of the hydronephrosis, formerly largely practised, is now reserved for palliation of severe cases causing pressure symptoms and in bilateral cases with anuria.

In the hydronephrosis of intermittent type, and perhaps those due to movable kidney, massage, properly used, with a retentive bandage, may be of service. Except when nephrectomy is indicated by conditions already stated, the operation is directed against the cause. If this should be found to be a movable kidney, nephropexy only is to be practised. In most other cases the hydronephrotic sac must be opened to determine the site and nature of the obstruction. If it be a stone in the ureter, a condition which can almost always be recognized before operation, it must be removed. As a preliminary to all further operative procedures, nephrotomy is the first step. In many cases a number of successive operations may be demanded before the condition is permanently cured.

In fully one-third of the cases the mere nephrotomy with drainage cures the condition without a fistula remaining, even if the obstruction is not found. The incision into the kidney or its dilated pelvis, exposed through an adequate lumbar incision, must be long enough to allow the free inspection and palpation of the interior of the sac, and the finding and the catheterization of the ureter from above, if this is possible. In very large sacs this is often impossible, and "it becomes necessary after the establishment of a fistula to wait for two or three months until the

sac has diminished in size before further operating for the obstruction can be done" (Fenger).

For obstruction of the ureter at or near the pelvic insertion the following methods have been practised: First, division of the valve-like spur between the ureteral lumen and the dilated pelvis. Second, division of the obstructing valve by a longitudinal incision and transverse suturing, as in the pyloroplasty of Heineke-Mikulicz. Third, resection of the ureter with direct implantation of the lower end into the lowest part of the dilated pelvis. Fourth, the establishment of a lateral anastomosis between the ureter and the dilated pelvis. This operation of ureteropyeloanastomosis was first practised by Albarran in 1898. Out of five cases, four were successful. Fifth, reduction in size of the dilated pelvis (*pyeloplication*) by the infolding of its walls by Lembert suturing. The operation is similar to that of gastroplication. By a number of operators this infolding of the renal pelvis has been combined with one or other of the operations above mentioned. Sixth, the reduction in size of the dilated pelvis by more or less extensive resection. This constitutes the "capitonnage" of Albarran. This operation, like the former, has in a number of cases been combined with operations on the valves.

Fenger collected thirty cases of plastic operations for hydronephrosis. Many operations have since been reported by many surgeons, and except in closed hydronephrosis of long standing, a secondary nephrectomy, on account of failure of conservative measures, became necessary in less than 20 per cent. of the cases reported.

Suppuration of the Kidney (*Pyelitis; Pyelonephritis* (*Surgical Kidney*); *Pyonephrosis; Abscess of the Kidney*).—Suppurative inflammation of the kidney may involve the pelvis and the renal parenchyma or both together or consecutively. The process is always of bacterial origin, the infection being either hematogenous and descending, or urogenous and ascending. Suppuration in the kidneys from direct blood infection may follow in the wake of any of the acute infections or after local and seemingly insignificant affections, like furunculosis or tonsillar abscess. Hematogenous infections of the mildest type may involve only the lining of the pelvis, as in the mild pyelitis which follows typhoid. In most instances hematogenous infections produce suppurations first in the parenchyma, from which the process extends to the excretory mechanism, the calices, and the pelvis. The unbroken pelvic lining resists infection. When the surface has been eroded, as by the presence of an irregular stone, the infection which occurs, producing suppurative pyelitis, is in reality hematogenous.

As a fruitful source of hematogenous renal suppuration the common colon bacillus has recently been recognized. Especially in children, Heubner and Baginsky have shown that diseases of the intestine are prone to produce renal suppuration.

In renal suppurations of the ascending type the area of infection is, as a rule, in the lower urinary tract. A stricture, chronic cystitis, or an enlarged prostate, by deforming the ureteral orifice and rendering it incompetent, will permit the upward development of an infection through

the ureter or through the lymph-channels in and without its walls. In women the cystitis of pregnancy and of the puerperium is especially important as a factor of pyelitis. Both in men and women gonorrheal infection plays a prominent rôle.

Although renal suppuration, which follows disease of the lower urinary tract, is as a rule ascending in type, it may be hematogenous and conveyed to the kidney through the blood-current, as from suppurative processes remote from the urinary tract.

From what has been stated, renal suppuration is produced by a great variety of micro-organisms. The common colon bacillus is the one most frequently found, and is believed by Guyon and his followers to play the chief rôle in infections of the upper urinary tract. Rovsing, on the other hand, believes that it is rather innocuous, producing bacteriuria, and by itself never produces destructive changes in the kidney. As a matter of fact, these are, as a rule, the result of mixed infections in which in the individual case varied cultures can be produced from the pus removed from the kidney by operation.

Pathology.—The appearances produced by renal suppuration vary much according to their origin and to the degree of patulousness of the lower urinary tracts. Hematogenous pyelitis as it is sometimes observed after the acute infections can hardly be said to have known pathology, since deaths from it are exceedingly rare. In the hematogenous pyelonephritis involving primarily the renal parenchyma the disease first manifests itself as multiple, minute abscesses in the cortex, giving to the surface of the kidney an irregular rough appearance. As the process continues, fusion of these foci takes place, and if the medullary portion was not primarily involved, this participates in the course of time, and eventually the pelvis becomes infected. Frequently a single large infarct may cause a single abscess. Very frequently the disease is bilateral.

In the ascending form the infection within the ureter and urinary stasis in the pelvis have generally already caused a distention of the pelvis. From here the infection spreads to the pyramids, where a number of suppurating foci may develop and eventually coalesce. As a rule, the obstruction causes the pelvis and calices to become dilated. The papillæ become flattened and atrophied by pressure and the cortex is narrowed; and the kidney as a whole becomes converted into a multilocular pus-sac. In rare instances the sac wall becomes calcified.

In traumatic cases the suppuration is limited to the injured portion of the kidney and usually presents itself as a solitary abscess.

Pyonephrosis is a dilatation of the pelvis and calices of the kidney with pus or pus and urine. The dilatation and suppuration may have progressed together. An uronephrosis may at any time by infection become a pyonephrosis. An obstruction of the outflow in any form of renal suppuration will eventuate in pyonephrosis. While a stone is the most potential of all the causes of pyonephrosis due to obstruction, the condition may result from obstruction by tubercular detritus or from an ulcerative ureteritis. The pyonephrosis complicating pregnancy usually

appears about the fifth month and is almost always on the right side on account of the inclination to the right of the gravid uterus.

In every form of renal suppuration perforation of the pelvis or cortex and secondary involvement of the contiguous tissues, preferably the perinephric areolar layers, may occur. In renal suppuration, as has already been seen, we have the most frequent cause of perinephric abscess.

Symptoms.—Acute hematogenous pyelitis without involvement of the parenchyma usually begins with chills and high fever. The urine contains pus, bacteria, and some few red cells. Palpation generally reveals some tenderness of the kidney, and thamuria, a not infrequent symptom, first directs attention to the condition. This pyelitis may disappear in the course of ten days or two weeks or may assume a chronic form without producing any constitutional manifestations. Chronic pyelitis may continue for years without impairing the functional capacity of the kidney. When the hematogenous infection, as it usually does, affects the kidney parenchyma as well as the pelvis, the symptoms are much severer. Frequently the patient rapidly succumbs with all the symptoms of uremia. In less acute cases, when it comes to the formation of single or multiple abscesses, the general manifestations of suppuration, with fever of continuous or remittent type, and recurrent rigors are present.

The ascending forms of pyelonephritis are, as a rule, ushered in with rigors, high fever, and marked tendency to collapse. Pain and tenderness in the region of the kidney are early symptoms, and in most cases bimanual examination will early reveal some enlargement of the gland. In rapidly progressive cases the patient sinks into a typhoid state with delirium and coma.

Pyonephrosis, in contradistinction to suppurating pyelonephritis, runs a more protracted course. Its earlier symptoms are those of the cause of the obstruction, whether it is a calculus, tuberculosis, prostatic disease, or cystitis. In regard to the latter it should be borne in mind that vesical symptoms are often produced by primary suppuration in the kidney.

In addition to the general symptoms of renal suppuration, pyonephrosis always presents a tumor varying greatly in size in different cases, and often in the same patient at different times. As in hydronephrosis, although to a less degree, a distinct intermittence of symptoms may come with drainage of the retained uro-pus through the ureter. Large discharges of pus at irregular intervals are distinctive of pyonephrosis, in contradistinction to pyelonephritis.

The urine in suppuration of the kidney and its pelvis requires careful study and interpretation. While in local circumscribed cortical lesions it may be normal, in all other conditions except a closed pyonephrosis it contains pus and the respective bacteria which have produced it. The club-shaped and laminated epithelia so often found are not characteristic, for they belong to the deeper vesical layers as well. Pus-cells in the form of casts indicate parenchymal involvement. Polyuria is not caused by disease of the bladder. It occurs in pyelitis with the involvement of the

pyramids by which resorption is decreased and the total quantity of urine proportionately increased. The probability that the suppuration is of the renal parenchyma occurs when the albumin found in the bladder urine is in excess of that due to pus, and the absence of casts makes it fairly certain that there are no non-suppurating inflammatory or degenerative changes.

Treatment.—Pyelitis as it occurs after the acute infections is treated by the internal administration of urotropin, benzoate of soda, and the flushing of the kidney. Similar medication is indicated in pyelonephritis until some enlargement of the kidney indicates pus retention. In chronic pyelitis, whether produced by the colon bacillus or gonococcus, some excellent results have been achieved by irrigating the renal pelvis through a ureteral catheter with mild solutions of protargol or of the nitrate of silver.

The prophylaxis of pyelonephritis is of paramount importance, since in the ascending type it follows septic infection of the lower urinary tracts. The utmost care regarding asepsis is imperative in all examinations of and operations on the lower urinary tract, if ascending pyelonephritis is to be averted.

When enlargement of the kidney indicates pus retention, the surgical *ubi pus ebi evacua* must be followed. In severe cases of pyelonephritis, even bilateral, some remarkable results have followed splitting of the kidney through a lumbar incision. In unilateral septic nephritis, nephrectomy was performed first by Woodward in 1895. Nephrotomy, according to Eisendrath, was performed in thirty-four cases, with twenty-eight recoveries, and in twenty-seven of nephrectomy there were twenty-five recoveries. When there is any question as to the condition being unilateral nephrotomy is the only justifiable procedure.

Abscesses drained in the same way have a distinct tendency to recover. Primary nephrectomy is rarely indicated here. Pyonephrosis must be treated according to the primary cause, the condition found, and the functional capacity of the other kidney. When the latter is in doubt or there is hope of saving the kidney, nephrotomy is indicated. The incision must be ample for drainage. Bisection of the gland with fixation of the two halves of the lips of the wound should be practised, as advised by Guyon and Albarran, who have applied the term "nephrostomy" to the procedure. Nephrotomy for pyonephrosis has a large mortality. Of seventy-eight nephrotomies, exclusive of tuberculosis, collected by me a few years ago, seventeen were followed by death. Israel placed the mortality at 40 per cent. After nephrotomy a secondary nephrectomy often becomes necessary. This should be done as soon as the sound condition of the other kidney is established, and if it is evident that a plastic operation cannot save the kidney. Long delay of the nephrectomy is dangerous. Of seventeen secondary nephrectomies I found seven recoveries and ten deaths. For secondary nephrectomies for pyonephrosis, Israel gives a mortality of 50 per cent.

The supposed advantage of nephrotomy that permits its easy and complete separation of the urine is apparent only. Unless there is com-

plete occlusion some of the excretion of the kidney comes into the bladder, and other means of establishing the condition of the kidney must still be resorted to. Pinner has suggested the tamponing of the upper end of the ureter with a catheter to produce such temporary occlusion.

Primary nephrectomy for pyonephrosis I have found to have a mortality of 24 per cent. in thirty-seven cases collected by me a few years ago. This mortality has been largely reduced by improved technic. Primary nephrectomy is indicated in pyonephrosis when there is a sound second kidney, and when inspection of the pus-sac shows many or large pouches that cannot be successfully drained; when there is little kidney tissue left; when an examination of the pelvis and proximal portion of the kidney makes it reasonably certain that a return to the normal cannot take place; in perinephric suppuration where the kidney may act as a valve, impeding successful drainage.

Renal Fistula.—As a sequel of suppuration within the kidney and perinephric abscess, renal fistulæ remain in a very considerable proportion of cases. The blocking of the upper end of the ureter by a stone or by valve formation due to distention of the pelvis from ureteritis or compression of the ureter from without gives rise to a continuance of a renal fistula through which pus and a greater or less quantity of urine are discharged. These fistulæ sometimes continue indefinitely and are a source of great annoyance. Although the wearing of a properly adjusted receptacle may mitigate the condition, every effort must be made to restore, by operation within the pelvis or above the ureter, the normal course for the urine. When plastic operations fail, nephrectomy is indicated. In old-standing cases, however, of renal fistula, the difficulties of the operation, by reason of very extensive adhesions, are very great. Under these circumstances the ligation of the renal vessels may be attempted, as in a very interesting case recently reported by Mr. Holt, in which, after several attempts at nephrectomy, the sinuses were permanently closed by tying the renal vessels through an abdominal incision.

Tuberculosis.—Miliary tuberculosis affects the kidneys in general dissemination of the disease and is always bilateral. It causes no clinical symptoms and never assumes surgical significance. In contradistinction to this form is the chronic, nodular, caseating, and ulcerating tuberculosis or scrofulous kidney of older writers, which, as surgery first demonstrated, is as a rule hematogenous in character and unilateral, and for a long time limited to the kidney alone. The right kidney is slightly oftener affected than the left. Autopsy reports show that unilateral disease occurs about as often as bilateral. This bespeaks the limitation of the disease to one side, at least in the beginning. Miliary tuberculosis occurs oftenest in children; surgical tuberculosis, in early adult life.

Etiology.—Cohnheim in 1882 first demonstrated the hematogenous nature of renal tuberculosis; that the kidney is an eliminator of the tubercle bacillus and that its localization within it is the cause of the disease. Until Steinthal in 1885 showed from autopsy records that in one-half of twenty-four cases the process began in the kidney, renal

tuberculosis was generally considered as a sequel to disease of the testicle, the vas, the prostate, or the bladder. That it often is simply a factor of urogenital tuberculosis is shown by Heiber, who found the proportion to be twenty-nine primary to fifty-five secondary and of urogenital origin. The separation of the genital and urinary tracts almost eliminates in women the latter form. Yet from a study of the operations of Morris, nineteen were in females and only six in males. Of Fackham's table of one hundred and three cases, seventy-three occurred in women. Of my own fourteen cases, eight occurred in women. This is a potent argument in favor of the primary nature of renal tuberculosis and that in most cases it pursues a descending rather than an ascending course. When both kidneys are involved, one gland is usually more diseased than the other, and the one may show the primary and the other the ascending or secondary type of disease.

Ascending miliary tuberculosis has been experimentally produced by Albarran and others, but only after the ureter has been obstructed, a condition which is somewhat like that following infection of the prostate and bladder when the primary focus is in the testicle or seminal vesicle. Tuberculosis by ascent is possible through the intramural or peri-ureteral lymphatics. The infection does not spread against the excretory current any more in the ureter than in the vas deferens.

Israel in four cases observed the simultaneous involvement of the kidney and the epididymis, the pleura, or the spine. As a rule, the capsule protects the gland from infection from without.

Pathology.—In specimens secured by operation tuberculosis of the kidney usually appears in the caseating form. The kidney, as a rule more or less enlarged, presents on section a number of irregular cavities varying in size and lined with a granulation tissue of worm-eaten appearance (Plate III). Disseminated through the cut surface appear small and large nodules in various stages of softening. The nodules vary in size from a pea to an olive. Often a number of small tubercles are arranged about one of larger size. If a secondary pus infection has taken place, the kidneys may present the appearance of an ordinary pyonephrosis, from which it can only be distinguished by microscopic study. In rare instances the kidney is reduced in size, presenting between the nodules firm bands of fibrous tissue, a condition similar to the fibroid phthisis of the lungs. These cases pursue a very chronic course. Frequently the first localization of the disease can be seen between the pyramids and the cortex, from which it extends toward the pelvis or the capsule, or both.

Early operations relatively often show the process limited to one pole. Partial resections have been based on this. In a specimen recently removed by the writer, the upper pole alone seemed involved. An examination after the operation showed the lower pole to contain three nodules potential of later trouble, if a resection had been done. The localization in one pole may be explained by the observation published in 1899 by Zondeck, that the lower pole often receives a separate arterial supply from the aorta.

With the involvement of the capsule and perirenal tissues, perinephri-

tis of caseating or suppurating form often follows. In cases of long standing the perinephritis assumes the sclerosing form. Chronic sinuses with purulent or uropurulent discharges often result from the invasion of the retrorenal connective-tissue planes.

Israel describes a rarer form of tuberculous ulceration of the apices of the papillæ, the pelvic mucosa and ureter remaining intact. In these cases profuse hematuria is likely to occur before there is any marked enlargement of the gland. In every advanced renal tuberculosis the

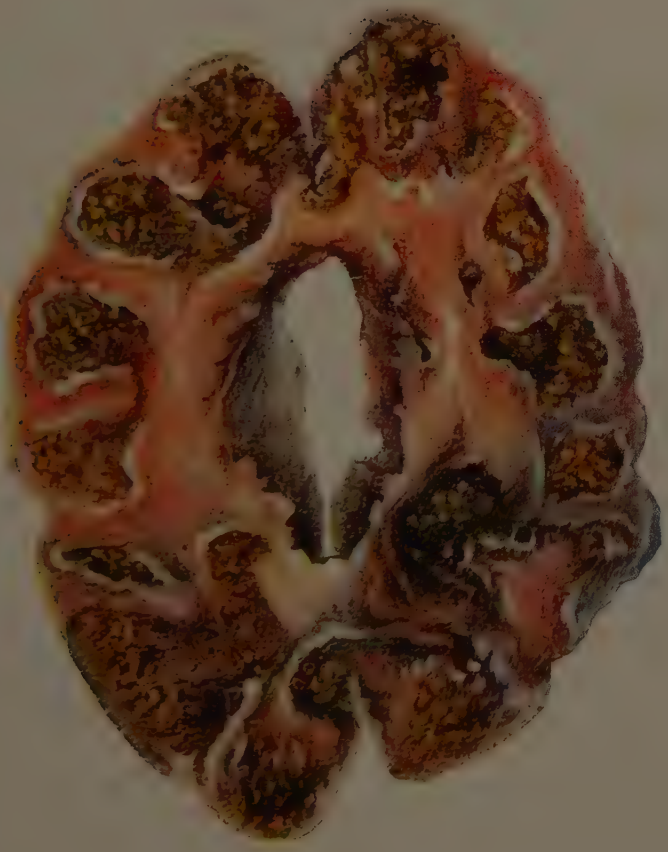
FIG. 124.—TUBERCULOSIS OF KIDNEY SHOWING THE DESCENDING PROCESS OF THE INFECTION (Lower).

The pelvis and upper part of ureter contain many tuberculous ulcers which gradually become less, entirely disappearing in the lower portion of the ureter.

ureter is involved. The process is most marked in the upper segment in the primary form and appears as small tuberculous nodules and ulcerations (Fig. 124). The ureter may be greatly thickened and stenotic, thereby causing renal retention. The bladder wall about the ureteral orifice in most cases shows a tuberculous cystitis.

Symptoms.—How long tuberculosis may remain latent in the kidney cannot be determined. Until a caseating focus breaks into the pelvis or until tension in the capsule gives rise to pain or tumor, there may be

PLATE III.



TUBERCULOSIS OF THE KIDNEY.

nothing to indicate its presence. The earlier symptoms are, as a rule, vesical. Thamuria, chiefly nocturnal, vesical tenesmus, and polyuria, in the order named, are generally the early clinical signs. Micturition is, as a rule, not painful until the bladder wall has been seriously affected. Every cystitis that is not gonorrheal, the result of instrumentation, trauma, or stone, must be looked upon with suspicion, especially in the young.

The urine at an early stage is turbid and, as a rule, of light specific gravity. Careful and repeated examination by centrifuging or sedimentation in conical glass will frequently demonstrate the bacillus. In negative cases inoculation experiments may be made. Shreds of detritus will often be found in the urine, in which the microscope may reveal connective-tissue fibers. Hematuria occurs often. Sometimes the disease is ushered in by hematuria, which rarely, however, is profuse as in neoplasms. As a rule, it is slight, even microscopic, irregular and capricious in its appearance and duration.

Until secondary infection with pus-formers results there is usually little fever, although the usual constitutional symptoms of the disease progressively develop. Renal colic from obstruction is not as pronounced as it is in stone.

A tumor distinctly palpable and tender on pressure presents itself early. The enlargement is rarely great until a condition of pyonephrosis exists. Variation in size of the swelling coincident with painful renal crises is not unusual.

If the disease is not arrested, its course is fatal in from two to four or five years, from extension of the disease to the bladder and the other kidney. Acute nephritis with uremia sometimes causes death at an earlier period. The diagnosis of renal tuberculosis must ordinarily be made from stone in the kidney and from disease of the bladder. Sufficient has been said elsewhere of the importance of cystoscopic examination and separation of the urines for this purpose. There, too, attention has been called to the importance of determining whether both kidneys are involved and whether the functional capacity of the one gland will be equal to double work in the event of its fellow being removed. A thorough examination of the genital organs in both the male and female is imperative whenever renal tuberculosis is suspected, particular attention being directed to epididymis, prostate, and seminal vesicles. Reitter has recently called attention to the lowered blood-pressure as almost constantly present in renal tuberculosis. This hypotonia, as shown by hemodynamometer, is a help to differentiate tuberculosis from other chronic kidney infections, in which, as a rule, blood-pressure is increased.

Treatment.—Climatic or medicinal treatment is indicated in renal tuberculosis when the disease is bilateral or part only of a general tuberculosis of the genito-urinary tract. In many cases I have known life to be prolonged and made comfortable by climatic change. In all other cases operative interference is indicated. Involvement of the bladder does not militate against operation, since the vesical symptoms frequently disappear with the removal of the primary cause in the kidney. In severe

cases where sepsis complicates an already badly diseased kidney, nephrotomy must be made even if the second kidney is known to be affected.

The first extensive tabulation of operations for renal tuberculosis after that of Gross in 1885 was that of Facklam. Of twenty nephrotomies, five died from the operation; seven within three weeks to one year; thus giving a mortality of 60 per cent. The general mortality of nephrectomy was 28 per cent.; of secondary nephrectomies, 37.5 per cent. Vigneron in fifty-four cases of nephrotomy found the immediate mortality 12 per cent.; the general mortality, 38 per cent. Albarran reports on twelve nephrotomies without one immediate death; seven died in from three to seven months, but only one survived two years. Israel in thirty nephrectomies had an immediate mortality of 10 per cent. and a late mortality of 17 per cent. Of seventeen nephrectomies by Küster, eleven remained well from one and a half to eight years. Of Kümmel's ten nephrotomies, three were fatal. Schmieden collected two hundred and one nephrectomies; 70.6 per cent. recovered; of seventy-four upon whom nephrotomy was done, 9 per cent. recovered; 24 per cent. retained a fistula; 37 per cent. required a secondary nephrectomy; 28 per cent. died.

The mortality of nephrectomy for tuberculosis is gradually being reduced. This in part is due to the careful inquiry into the state of the other kidney by modern methods. Of seventy-six nephrectomies, Kümmel lost five; of sixty-five following the use of ureteral catheterization, only two. In Casper's report of one hundred and twenty-nine nephrectomies, there was a mortality of 21 per cent. before, and in one hundred and thirty a mortality of 10 per cent. where catheterization was done. Rovsing, who first compared his cases carefully, does not attribute the same value to ureteral catheterization in reducing the mortality. Personally I believe that the individual operator's improved technic is largely responsible for the improved statistics.

In 1887 Czerny first performed resection of the kidney for tuberculosis. In 1899 I was enabled to collect sixteen cases of erasion or partial resection, all of which recovered from the operation. In a number of these recurrence necessitated secondary nephrectomy. As already indicated in the considerations of pathology, resection affords no assurance that nodules will not be left in the remaining part of the gland.

The routine operation for primary tuberculosis of the kidney is lumbar nephrectomy. Whenever feasible the ureter, if involved, is to be removed as far as possible. In many cases this cannot be done at the first operation, and ordinarily no fistula remains, the ureter becoming cicatrized and innocuous. If it does give rise to a fistula, it may be removed at a later period.

Nephrotomy is indicated only when there is uncertainty as to the condition of the opposite kidney or for the relief of acute sepsis, or if the condition of the patient will not permit the major operation. It is to be followed as speedily as possible by nephrectomy.

The incision should be made long enough to permit the removal of the kidney with as little handling as possible. Local infection and even dissemination of the tuberculosis has occurred after nephrectomy.

The end results of operations are not as good as the immediate, for in some cases death occurs at a later period from tuberculosis elsewhere.

Syphilis of the Kidney.—At any time in the course of acquired or hereditary syphilis the kidney may become infected. As a rule, the disease is bilateral and consists of microscopic changes in the parenchyma, and belongs, therefore, to internal medicine. In very exceptional cases gummata are formed in the kidney during the tertiary period of syphilis and in the congenital form. Such gummata have been found in a number of autopsies, and the kidney has been removed in two cases by Israel and one by Bowlby.

This diagnosis must be based upon the previous history. In most instances a malignant neoplasm was suspected. In the cases in which nephrectomy was performed recovery ensued.

Actinomycosis.—Secondary actinomycosis of the kidney as a part of infection of the abdominal organs has been repeatedly observed. As a primary disease Israel has reported one case in which the diagnosis was made intra vitam from the presence of the characteristic yellow granules in a lumbar fistula and the discovery of the ray fungus in the urine. (See vol. I, p. 516.)

Stone in the Kidney and Ureter.—The inability of the urine to hold certain of its saline organic and inorganic constituents in solution is the primary factor in the causation of stone in the kidney. Both sexes are equally disposed to it. The first decade and the third and fourth predispose to stone formation. In children stone in the bladder occurs oftener than kidney stone.

The frequency of stone in the kidney and ureter is shown by the statistics of Tenny. In thirty-eight hundred and seven autopsies in the Boston City Hospital stone was found in either kidney or ureter twenty-one times and gall-stones one hundred and forty-six times. During the same time there were admitted to the hospital wards one hundred and nine cases of renal calculus and four hundred and eighty-nine of gall-stone, showing that kidney stones are much more likely to produce symptoms than gall-stones.

Epstein has shown that besides the crystals and urinary salts, every stone except the cystin has an organic framework or matrix about which the concretion is formed. Latterly this view has been questioned. Stones in the kidney are either primary or secondary. The first consist of uric acid, urate of sodium and ammonium, oxalate of lime, carbonate of lime, and lastly of cystin or xanthin. They are deposited from the urine without any changes of an infective nature. The secondary calculi, consisting for the most part of phosphate of lime, develop only in a kidney already the seat of infection. As a result of this, a primary calculus is often encrusted with phosphate of lime. Secondary stones occur often as a complication of spinal-cord lesions. Injury of the kidney and mild pyelitis are occasionally the cause of stone, through leaving their products, namely, epithelial detritus, fibrinous deposits, or small blood-clots, as a focus for the deposit of salts. The number, size, and location of stone vary widely. As a rule, a single stone is found, but eight or ten are not

uncommon. Rovsing removed a stone weighing fourteen ounces; Shields one of nineteen ounces. Barrow, of Lexington, recently removed with the kidney a stone weighing sixteen ounces. Formed stones not infrequently weigh ten grains or even less. The urate stones removed by myself, and shown in Fig. 117, weighed nine grains.

Fig. 125.—Renal Calculus (Keen).

According to Küster's statistics, stone was found in both kidneys in ninety out of seven hundred and sixty-four cases. The right kidney contains a stone oftener than the left. Legue believes that the stone is bilateral in 50 per cent. of cases.

Pathology.—The location of stones in the kidney varies greatly. Although they may be found in the cortex, their usual situation is in the pelvis or in one of the calices. Here the position of the stone often causes it to assume a coral shape and become a more or less exact cast of the pelvis and calices. Frequently a stone is also formed in the ureter, and in rare cases (Fig. 129) the renal pelvis and the ureter are filled with a continuous row of calculi. Stones lodged in the ureter are usually elongated, and sometimes present a gutter through which the urine passes without obstruction (Fig. 117). In such cases the kidney is not damaged.

Stones may be fixed or movable. In the latter condition they may, if small, pass through or become lodged in the ureter during a renal colic. If too large to enter the ureter, obstruction with retention results. With dislodgment of the stone this disappears. A condition of hydronephrosis, sometimes intermittent, may result.

Fig. 126.—Branched Kidney Stone.

Much depends on the aseptic or septic condition of the kidney harboring a stone. In the former condition chronic interstitial changes occur in the kidney and not infrequently extend beyond even the fibrous capsule. Induration of the perirenal tissue is often observed in operations for kidney stone. In the aseptic kidney the stone, particularly if large, may become adherent to the pelvic mucosa, which then becomes extremely vascular.

When the renal pelvis becomes infected with pus-formers, a condition of calculous pyelitis results, which frequently eventuates in pyelonephritis, and oftener in pyonephrosis. Perinephric abscesses occasionally develop. In a number of cases stone has been the forerunner of malignant disease.

In a case reported by the writer a sarcoma developed in the kidney a number of years after a positive diagnosis of stone had been made. Renal lipomatosis occasionally accompanies chronic nephrolithiasis.

Symptoms.—A stone, often of large size, may be carried for many years and lead to destruction of the kidney without giving a sign of its presence. I removed one weighing over an ounce from a man of twenty-one. With the exception of one day in bed after an injury from a base-ball, he had never known a day's illness. A large lumbar abscess opened spontaneously while the patient was at work. He sought relief from the fistula which resulted. Until his attention was called to the almost milky appearance of the urine he did not know that anything was wrong.

FIG. 127.—CALCIFIED PYONEPHROSIS.

In a broad way the symptoms of kidney stone may be divided into two groups: first, those due to renal colic proper; and, second, those due to processes constantly going on in the kidney, because of its containing a stone, a condition of chronic nephrolithiasis. Renal colic is an inconstant symptom. In a very large number of cases there is no renal colic from beginning to end. It is supposed to depend upon the passage of a stone through the ureter, or on the impaction of the stone in the pelvic outlet. Many times the stone is voided in the natural way soon after being formed. These are the cases that ordinarily do not require surgical intervention. As has already been seen, the colic depends not so much upon the passage of a stone as upon the increase of intracapsular renal tension.

The onset and end of a renal colic are, as a rule, quite sudden. Nausea and vomiting are often present and accompanied by varying degrees of shock. Pain, often agonizing in character, is felt in the loin and shooting toward the bladder, groin, testicle, and thigh. Reflected pains may be experienced in the course of the crural nerve as far as the toe. Retraction of the testicle is not unusual, and irritability of the bladder and strangury are often harassing.

When the stone is firmly fixed in the kidney and produces no colic, the

symptoms of chronic nephrolithiasis must be depended upon for diagnosis. Pain elicited by pressure, changes in the urine, and the frequency of its expulsion are the symptoms indicative of aseptic changes in the kidney, before it has come to palpable enlargement. The urine affords the most valuable single sign in a persistent microscopic hematuria. Almost every specimen contains a few red cells in the field. Macroscopic bleeding occurs after renal colics, but rarely is profuse. Crystals in the urine are of very little diagnostic value. Except when a stone is in process of growth, they can hardly be expected. The patient with kidney stone does not often pass sand with his urine. Casts are often found as a result of degenerative changes in the parenchyma.

When an infection takes place, a persistent pyuria is present. The urine for the most part is little more than turbid. Enlargement of the kidney reveals itself only when a uronephrosis or a pyonephrosis occurs from retention. The body-temperature in nephrolithiasis is of little importance. In a few of my cases I have observed the colic itself to be associated with fever, and that without any permanent septic involvement. In chronic nephrolithiasis that is infected, slight elevations of temperature, continued through a long period and with a tendency to recur irrespective of any renal colic, are often observed.

The importance of radiography in the diagnosis of renal and ureteral stone has already been considered (p. 196). In a very considerable number of cases H. A. Kelly has demonstrated the presence of a stone by the use of a wax-tipped ureteral bougie, on which the stone produced scratch-marks.

The diagnosis of stone in the kidney between the attacks is made relatively easy by radiography. Before this examination can be made, stone must be differentiated from vesical affections and those of the prostate, chiefly from tuberculosis. The renal crisis itself must be differentiated from other abdominal crises, notably gall-stone colic and acute appendicitis. Neuralgia of the lower intercostals may simulate a renal colic, but all of these conditions can be excluded by a careful attention to urinalysis.

Prognosis.—Although a kidney stone may be quiescent for many years, it is always a menace to life, either by causing anuria or by producing grave changes in the pelvis or parenchyma of the kidney. With infection and retention well established, recovery does not ensue. If untreated, destruction of the kidney by suppuration or lipomatous transformation takes place. Small stones formed at different periods may be passed. Such attacks of renal colic followed by the passage of a small calculus may recur from time to time without endangering the kidney. In rare instances stones have been known to break up in the kidney and to be passed as fragments. The process by which this disintegration occurs is not known. The accompanying illustration (Fig. 128) shows fragments passed in this way.

Treatment.—The medicinal treatment consists in restriction of diet and the administration of diluents and of agents to reduce the tendency to hyperacidity. When pyelitis exists, urotropin, benzoate of soda, and methyl-blue may be used to modify the condition.

The surgical treatment of stone in the kidney is its removal by operation. This is imperative in anuria and where hematuria is profuse. Pyuria as an evidence of beginning destructive changes is a positive indication for operation. Although stone in the kidney is attended with less suffering than stone in the bladder, it is fraught with infinitely greater danger to life. The operations for kidney stone are nephrolithotomy, nephrotomy, and nephrectomy. Nephrolithotomy was first performed in 1882 by Henry Morris for the removal of a stone from a healthy kidney. This operation is nearly devoid of danger. Morris himself reported thirty-four aseptic operations with one death; Tuffier, eight without a death. Of nineteen cases of my own, one death resulted from intestinal obstruction from tight packing of the wound. I have also lost one case from shock after a negative exploration. According to Rovsing, there is a mortality of seven out of one hundred and fifteen cases. Nephrolithotomy in an aseptic kidney requires no drainage of the pelvis.

Fig. 128.—Some of the Fragments of Stones Disintegrated and Passed per Urethram. Magnified 3½ times.

Nephrotomy is the operation in septic cases. Morris lost ten out of forty-three. Drainage of the kidney wound is always indicated, and in a considerable proportion of cases secondary nephrectomy must be performed.

Primary nephrectomy for stone is rarely indicated. It may have to be performed for profuse hemorrhage following the removal of large and adherent stones.

In nephrotomy and nephrolithotomy the kidney is to be opened by an incision through the non-vascular zone of Hyrtl, a little behind the convex border. An incision not longer than is needful for the introduction of the exploring finger should at first be made. This makes the hemorrhage *nil*, while the search for the stone progresses. A short incision over the upper pole and another over the lower will allow an examination with the finger of both the upper and lower and the common pelvis. The so-called post-mortem section should be reserved for cases in which the finding of the stone is very difficult.

Experiments by Paoli, Tuffier, Barth, and others have shown that by this section degenerative changes are reduced to a minimum. Griefenhagen had an opportunity to examine two kidneys treated by sutures after operation. A linear and depressed cicatrix, narrowing toward the pelvis and firmly adherent to the capsule, was present in each kidney as the only vestige of a previous incision. I have seen in one case

the same limitation of scar tissue one year after a nephrotomy and suture.

Hemorrhage during the exploration is easily controlled by the fingers of an assistant or by throwing a temporary ligature around the pedicle. Retrograde sounding of the ureter is essential to every operation for stone in the kidney. Needling of the kidney for finding a stone has been justly discarded. To render the operation easy the incision should be long enough to permit the free delivery of the kidney into the wound. In rare cases an incision made through the pelvis directly upon the stone is indicated.

The operation is finished by closing the kidney wound with buried catgut sutures through the substance of the kidney. This is justifiable even in cases of pyelitis, if the ureter is competent to act as a competent drain. An exception must be made in regard to immediate suture in those cases of even aseptic nephrolithotomy in which anuria compelled operation.

In calculous pyonephrosis incision and drainage must always be first resorted to, in view of the frequency of the involvement of the second kidney. When the kidney is sacculated, if it be split widely and the margins of the wound in the kidney stitched to the skin, shrinking of the sacculation often takes place and the kidney gradually resumes a form something like the normal.

According to Küster, both kidneys have been operated upon in twenty cases. The first was reported by Clement Lucas. I myself have had one.

Calculous Anuria.—The gravest result of the presence of a stone in the kidney or ureter is the suppression of urine which it may induce. It is produced by the obstruction of one ureter, when the kidney of the other side has been practically destroyed or in a reflex way has ceased to perform its function. In rare cases simultaneous obstruction of both ureters has taken place. Tumor masses or twists of the ureter may produce anuria, but stone is its common cause. It has been observed after nephrectomy, and relieved by nephrotomy of the remaining kidney. The suppression of the urine may be complete from the beginning of the renal crisis, or the quantity may be greatly reduced at first, soon to cease altogether. Death follows from uremia in from five to twenty-five days, unless the obstruction is relieved spontaneously or by operation. The treatment, consisting of hot baths, saline transfusions, and chloroform anesthesia, with the view of relaxing the ureteral spasm, should be given a trial. If after two or three days the anuria continues, operation is peremptorily demanded. Lucas advises operation after forty-eight hours. Cases operated on early, according to Luegue, present a post-operative recovery of 66 per cent.

The operation to be performed is nephrotomy and drainage, unless, as is rarely feasible in acute cases, the location of a stone in the ureter can be determined. The kidney to be explored is the one on the side last affected by a renal colic. Errors have been made in this regard and an operation on the other kidney within twenty-four hours has saved the patient.

Nephralgia (*Essential Hematuria; Hematuric Nephralgia; Angioneurosis of the Kidney*).—As a consequence of rheumatic or gouty diathesis with marked recurrent hyperacidity of the urine, severe neuralgic pains are not infrequently experienced in the region of the kidney. They belong to the domain of internal medicine. This also pertains to the renal crises of locomotor ataxia described by Raynaud in 1876. Severe neuralgias are encountered as a common factor in the symptom-complex produced by most gross lesions of the kidney, such as stone, tuberculosis, obstruction of the ureter, and neoplasms. Within the last twenty years cases have multiplied in the literature of typical renal colic, supposedly due to stone, in which gross lesions were not found either upon operation or at autopsy. In 1894 I collected forty-four cases. Severe pain and hematuria varying in degree were the chief symptoms. With the perfection of radiography, negative results, so far as finding a stone, will be less often encountered.

Sabatier in 1889 originated the euphonious term "hematuric nephralgia" to designate this group of symptoms—a term which defines concisely but fails to explain. This is curious, since in one case he found a slight inflammation of the kidney, the importance of which in the causation of symptoms he failed to recognize. The criticism of defining without explaining applies to the more recent terms of "essential hematuria" and "renal hemophilia." The use of these terms is justified when the non-existence of inflammatory or other changes in the kidney has been demonstrated by minute examination of post-operative specimens or by postmortem. How difficult this may be, and how slight the changes are, is illustrated by a kidney removed for essential hematuria and presented by Nickolish to the Paris Academy three years ago. In Vienna the kidney was pronounced normal; in Paris, Albarran and Motz found marked evidences of glomerulonephritis. That profuse bleeding from the kidney can be a symptom of hemophilia, of various forms of toxemia, and of arteriosclerosis without local changes in the kidney is not to be questioned. It has been noticed from normal kidneys after very prolonged exercise, notably long-distance horseback rides. Barring these conditions it very rarely occurs from normal kidneys. Altogether not more than nine cases have been reported. Casper, Wulff, and Steinthal have recently reported cases from normal kidneys. Young has recently reported a case of unilateral renal hematuria cured by injection of adrenalin through a ureteral catheter.

Nephralgia and profuse hematuria have been shown by a number of observers since Naunyn first called attention to it to be not infrequently caused by diffuse nephritis, which was not revealed by urinalysis. In unilateral disease, and even when both kidneys are affected, the pain may be unilateral. Because patients thus affected often have recurrences of symptoms without impairment of the general health, is no evidence of the absence of structural changes in the kidney. Colic and hematuria are the result of increased renal tension. I operated on one of these cases in which the pain had lasted for fourteen years. The examination of a portion of the kidney removed by operation showed that,

although the glomeruli generally retained their normal appearance, in certain areas distinct atrophy with granular changes had occurred. On looking at the apparently normal kidney structure in the slide the quantity of red blood-cells within and without the blood-vessels stands out in bold relief. This may have resulted from handling of the kidney incident to the operation. There was no overgrowth of connective tissue. The operation was performed five years ago and the patient has continued well. Angerer reported a case where nephrectomy was performed and a chronic interstitial nephritis found. Based on fourteen cases, Israel concludes that a very large number of the cases designated as idiopathic or hematuric nephralgia are due to inflammatory changes in the kidney.

Bright's Disease and its Surgical Treatment.—That there is a unilateral, atypical, chronic nephritis giving rise to symptoms chiefly simulating stone is established by many cases which have been relieved by capsule splitting or nephrotomy. These results perhaps suggested to Reginald Harrison the idea of reni-puncture for the treatment of "some forms of albuminuria associated with kidney tension." Decapsulation of the kidney as a recognized treatment in chronic Bright's disease was reported first by Edebohls in 1899, after an experience of nearly seven years with the operation. In acute cases where uremia is threatened, after scarlatina, or in toxic cases, as after extensive burns, the relief of tension by capsulotomy is justified. Four cases of puerperal eclampsia have been relieved by capsulotomy—three by Edebohls and one by Pousson. Lennander advises this nephrolysis in acute cases in which pain and tenderness on one or both sides indicate the increased tension. In regard to chronic affections of the kidney, some of the conclusions of Israel are noteworthy: First, there is such a condition as unilateral nephritis. Second, nephritis may produce kidney colics closely simulating those of stone. Third, unilateral colic may be present when the disease is bilateral. Fourth, chronic nephritis may exist without albuminuria or casts in the urine, and albumin may be absent in the presence of casts of various kinds. Fifth, profuse hemorrhage with or without colic may occur in chronic nephritis.

The object of decapsulation and capsulectomy in chronic Bright's disease is the production of a new and increased blood-supply to the cortex of the kidney from the surrounding tissues, by which regeneration of the renal parenchyma is to be made possible. Experiments have been made by many observers which show that a new capsule is formed and that increased vascularization follows the operation. A prolonged and beneficial effect on the functional capacity of the kidney has not been demonstrated. Up to December 1, 1903, Edebohls operated on seventy-two patients. In sixty-eight cases both sides were operated upon. Nine per cent. died within two weeks; twenty-two, some time later. Seventeen cases, according to Edebohls, were cured. The results of Edebohls have not been confirmed by other operators. It may be said that for the present in chronic Bright's disease, if operation is at all justified, it should be limited to cases in which pain is a marked symptom or in which pro-

fuse hematuria or anuria threatens life. In these cases the operation should be limited to capsulotomy.

Cysts of the Kidney.—Cysts of the size of a pea are often found in contracted kidney as the result of occlusion by cicatricial contraction. They are of pathologic interest only. Larger cysts of the kidney may be classified as follows: First, simple serous cysts; second, hydatid cysts; third, polycystic disease; and fourth, dermoid cysts.

The simple serous cysts, usually single, though sometimes multiple, are ordinarily not larger than an apple, but sometimes as large as an ovarian tumor. These cysts are, as a rule, thin walled, and usually occupy one pole of the kidney, but may spring from within. Tuffier in seven cases found the cyst attached to the upper pole six times. The contents are serous or at times gelatinous, and sometimes colored by blood admixture. The kidney tissue itself is not involved.

In most cases the origin of the cysts is unknown. In some cases they have followed a trauma.

The **symptoms** are, as a rule, negative, until a tumor is discovered. The growth of this is usually slow, and no urinary symptoms indicate its connection with the kidney. The diagnosis must be based upon the presence of a fluctuating tumor, which from the history can be shown to have grown in a downward direction. The condition has been mistaken for cysts of the liver, and in large tumors for ovarian disease.

The **treatment** consists of tapping when the diagnosis is certain. Some cures have been effected. In some cases a lumbar incision with drainage must be made. Fistulas quite often remain, which may demand a secondary nephrectomy for their relief. Under favorable conditions the cyst has been extirpated. The abdominal route has, in a large proportion of cases operated upon, been resorted to on account of errors of diagnosis.

Hydatid Cysts.—In about 4 per cent. of all cases of echinococcus the kidney is the seat of a hydatid cyst, the left kidney being the host twice as often as the right. Frequently other organs, notably the liver, are affected. Kümmel in one case found the disease bilateral. I found no case reported in American literature. Echinococcus cysts are as a rule single, and possess a capsule growing in thickness with the growth of the cyst until it may measure one-half inch or more in thickness. Adhesions form to contiguous organs and rupture may take place into them. It oftener takes place into the renal pelvis (fifty-two out of sixty-five cases, Roberts). The cyst contents are then discharged through the urethra. The contents vary as those of similar cysts elsewhere in regard to the presence of daughter cysts. The kidney tissue itself may be but little changed.

The **symptoms** are negative until an appreciable tumor develops, and then often the diagnosis is impossible, until aspiration or urinalysis indicates the nature of the cyst. The urine contains hooklets or vesicles. In a few cases radiography has demonstrated the presence of a rounded chalk-infiltrated sac. Hydatid fremitus has very rarely been observed. Hydatids of the kidney grow often to enormous size and then lead to

suppuration. Occasionally rupture into the bronchi takes place. The pressure effects in large cysts are those common to other tumors of the kidney. The **treatment** of echinococcus of the kidney consists in the incision of the sac, with nephrotomy if necessary. The operation should always be a lumbar operation where the diagnosis is clear. Removal of the contents of the cyst with drainage completes the operation. In rare cases enucleation of the cyst has been feasible. Primary nephrectomy is never indicated.

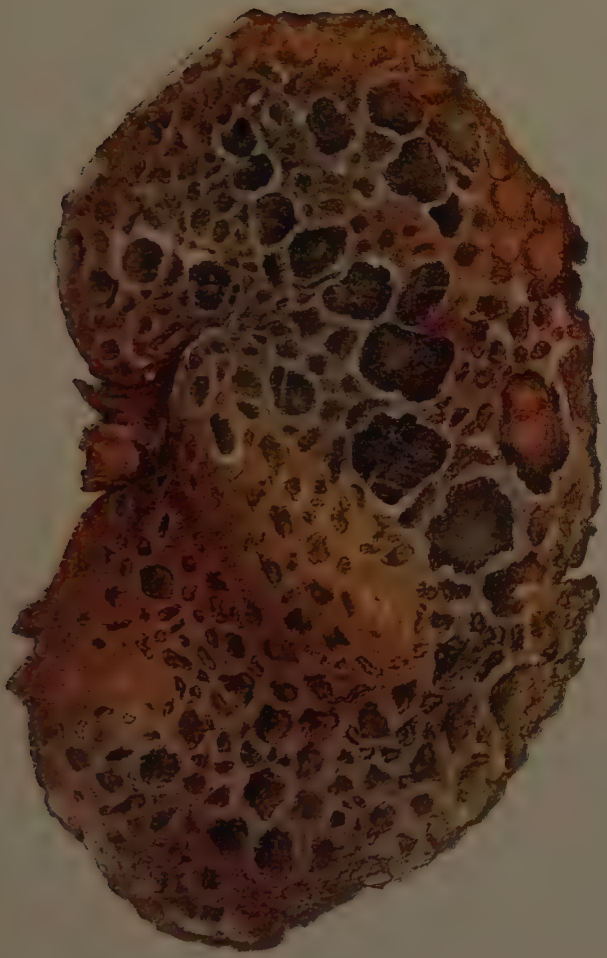
Polycystic Kidney.—Polycystic disease of the kidney, bilateral in a great number of cases, causes enormous enlargement of the kidney on account of the presence within it of an infinite number of cysts, between which renal tissue more or less capable of function intervenes. It is often congenital in character and may, by its size, form an impediment to natural delivery. According to Sieber, thirty-two cases have been reported between the eighth week and twentieth year. Of two hundred and twelve cases, one hundred and fifty-five were seen between the twentieth and sixtieth year. Cystic disease elsewhere, particularly of the liver, is often found. Heredity is often manifested. Lejars found it seventeen times in sixty-two cases. As a rule, the kidney is threefold or fourfold its natural size. In a case recently observed at the Cincinnati Hospital, the larger kidney measured twelve inches in length. The surface of the kidney is very irregular, and on section the kidney, in all its parts, is occupied by a multitude of cysts varying in size and often communicating with each other. The contents of the cyst are clear, serous, and gelatinous, and not infrequently colored by admixture of blood. The walls of the cyst are of fibrous connective tissue and lined with cuboidal epithelium. (Plate IV.)

The nature of polycystic degeneration of the kidney is entirely unknown. It is not improbable that it varies, some cases of congenital character being due to abnormal growth of aberrant Wolffian bodies (Küster), whereas in others the disease seems to be of the nature of cystadenoma.

The **symptoms** are very inconstant. Many cases are discovered by autopsy, death resulting, as a rule, from uremia (fifty out of ninety-eight cases, Sieber). Renal colic, hematuria, gastric disturbances, and pressure symptoms may direct attention to the kidney, where the discovery of a tumor causes the first indication of kidney disease. The urine may be normal, but may increase in quantity and contain albumin at intervals. According to Sieber, the diagnosis was made intra vitam in twenty-one cases. The progress of the disease is very slow, and its course may run through many years. Polycystic kidneys have been found in persons of eighty years. Suppuration occasionally occurs.

The **treatment,** where the diagnosis can be made, must be palliative. Nephrectomy has been performed in sixty-two cases, mostly under a mistake in diagnosis. Twenty of those cases ended in death. Nephrotomy with drainage has been performed in ten cases with 30 per cent. mortality. These statistics show that for polycystic kidneys operative interference is contraindicated except for the relief of sepsis resulting from infection.

PLATE IV.



Polycystic Disease of Kidney (Cincinnati Hospital Museum).

Dermoid cysts of the kidney are exceedingly rare, only four cases having been recorded; one of these by E. W. Walker, of Cincinnati. In this case nephrectomy was successfully performed. The kidney presented three distinct dermoid cysts filled with epithelial detritus and hair. A number of serous cysts were also found. In Madelung's case death resulted from sepsis. The symptoms in the cases reported have been those of a tumor or of a hydronephrosis of moderate degree. The diagnosis cannot be made until a section of the kidney is made.

Tumors of the Kidney.—Although all forms of tumors have been found in the kidney, renal neoplasms are comparatively uncommon. Küster, in over thirty-seven thousand cases, found only two hundred and twenty-three kidney cases, and of these only twenty-three were tumors. Kelynack found only nine primary renal growths in over forty-five hundred autopsies. As compared with tumors in general, and especially malignant growths, the kidney is the host in about 2 per cent. of all cases. The relative frequency of the various forms of tumors, from an examination of one hundred and fifty-four cases, is given by Morris as follows:

Sarcomata	63
Carcinomata	41
Cystic degeneration	21
Hydatid cysts	11
Adenomata	10
Papillomata	3
Myxomata	2
Lipomata	2
Dermoid cyst	1
	154

Secondary tumors occur in the kidney as a result of carcinomata and sarcomata. Thus, of one hundred and twenty-six carcinomata, ten presented secondary deposits in the kidney; and of sixty-nine sarcomata, the kidney was also affected in ten.

Renal growths occur particularly in early life, and again after the fourth decade. According to Rohrer, over one-third of all cases occur in childhood. Of one hundred and fifteen, thirty-seven occurred under ten and thirty-one of these under five years. In one hundred and sixty malignant cases examined by Kelynack, 52 per cent. occurred below the age of ten years. No less than seventy-four cases were met with below five years. A number of congenital cases have been recorded.

Tumors of the kidney may be divided into the malignant and the benign.

Malignant Tumors.—To the former, which form by far the largest class, belong carcinomata, sarcomata, and suprarenal inclusion tumors or hypernephroma. The predisposition to malignant disease in early childhood is remarkable. Rosenstein, from computation of five hundred and forty-eight cases, finds 30 per cent. during the first decade. It appears to occur oftener in men than in women. Cancer of the kidney may occur in every variety of carcinoma, but occurs oftenest in the medullary form. Alveolar carcinoma is very rare. Primary carcinoma has hitherto always been unilateral; secondary disease often bilateral.

Cancer of the kidney appears as a solitary tumor or in the form of diffuse infiltration. In the solitary form the tumor, varying greatly in size, usually occupies one pole and springs from the cortical substance. In the diffuse form the cortical substance is also chiefly involved. Medullary carcinoma of the kidney often gives rise to tumors weighing eight to ten pounds. Secondary fat degeneration or hemorrhages into the tumor frequently give rise to cysts, which may largely make up the bulk of the growth. Quite often processes of the tumor grow into the pelvis or the renal veins. Adhesions to contiguous organs rapidly ensue. Histologically these growths seem to be derived from the epithelia of the uriniferous tubules. Frequently in conjunction with the carcinoma, adenomatous masses are found. To this condition the term "adenocarcinoma" is applicable, but true adenomata of the kidney are practically never found.

Sarcoma of the kidney more often than carcinoma is a disease of the first decade. Even in young children the tumor may weigh eight or ten pounds. Cysts are of common occurrence within them. Round and spindle-celled sarcomata have been found and ofttimes smooth and striped muscle-fibers have been seen. The great vascularity of some of the rapidly growing sarcomata of the kidney justifies the application of the term to them of angiosarcomata. The frequency with which these growths are found in the very young have led to investigations, notably by Birch-Hirschfeld and Wilms, which show that they differ from the sarcomata of later life in that they are often mixed and that elements from the three primary embryonic layers are found. (See Plate V.)

Hypernephroma or struma of adrenal origin, sometimes called the tumor of Grawitz, consists of the growth of aberrant adrenal gland masses within the substance of the kidney. Aberrant adrena tissue may be found also without the capsule. Grawitz showed that the hypernephroma consists of epithelial cells arranged in cylindric and columnar form, and in groups, as they are normal in the suprarenal bodies. The cells themselves are unlike those of the kidney proper, and are like those of the parent body from which they spring. Furthermore, the chemical properties of the hypernephromata bespeak their origin from adrenal rests, in that they contain glycogen.

Hypernephromata on section are either flesh-colored or canary yellow. Although, as a rule, uniform on section, softened areas and hemorrhages are often seen. (See Plate VI.) They are usually rounded in outline and form protrusions covered by the kidney capsule. As a rule, the tumor mass is separate and distinct from the kidney tissue. When small, they are almost always confined to the cortical substance or medulla. Either pole of the kidney may be involved. As it grows, the tumor reaches the pelvis and may extend as do tumors of the adrenals, particularly along the veins, and invade even the vena cava.

Small hypernephromata may clinically be non-malignant. Larger growths distinctly tend to metastases. These have been found oftenest in the lung, in the liver, and in the long bones. In a considerable number of cases supposed primary sarcomata of the long bones, more rarely of the

PLATE V.

Sarcoma of Kidney Growing into Pelvis.

flat, have, after operation, been shown to be metastases from undiscovered hypernephromata. Hochenegg found a metastasis in the mediastinal glands ten years after nephrectomy.

Hypernephroma occurs somewhat oftener in males than in females. The age of the patients is fifty-two. Of one hundred and sixty-three cases collected by Ellis, one hundred and fifty-seven were in the kidney, three in the adrenals, two in the liver, and one in the uterus. The frequency of hypernephroma may be indicated by the fact that Albarran and Imbert give the number of tumors of the kidney reported from 1890 to 1902 as five hundred and eighty-eight. Seventeen per cent. belong to the hypernephromata. In ten years twenty-eight cases were observed in the second surgical clinic of Vienna. I myself have operated on two cases.

Symptoms.—Malignant tumors of the kidney may remain latent for a considerable length of time. Until the detection of a tumor affords the only positive symptom of renal growth, hematuria and pain are the chief factors directing attention to the kidney. Unfortunately, a tumor is often not found until it has attained considerable size.

Hematuria with or without renal colic is the most constant symptom, and according to Israel, is found in 70 per cent. of the cases as one of the earliest symptoms. The hemorrhage is ordinarily spontaneous, very profuse, and its end is as sudden as its beginning. The intervals between the hemorrhages may vary from a number of days to many weeks and even months. In cases of hypernephroma an interval of five years has been observed between the attacks. In benign growths hematuria is not a conspicuous symptom. In hypernephroma which in its beginning is encapsulated, hematuria is less frequent than in other malignant growths. In twenty-six cases carefully examined by Phaulner, hematuria was present in seven. Hochenegg found it eleven times in twenty-eight cases. The hemorrhage is due to extension of the growth into the renal pelvis or, in the absence of this, to venous stasis by pressure.

Other changes in the urine are rather infrequent. In the intervals microscopic hematurias have often been observed, although in most cases urinalysis is negative. Separation of the urines, therefore, is of less value for diagnostic purposes than in other surgical affections of the kidney.

Pain is an almost constant symptom in adults. In children I have observed large renal tumors pursue a painless course. The pain is ordinarily of dull aching character, and more rarely of lancinating nature.

Cachectic symptoms with emaciation and secondary anemia develop late, although in some cases there is a very rapid loss of weight.

Fever, according to Küster, was found in thirteen cases. Hochenegg found it three times in twenty-eight cases; this, too, when sepsis could be positively excluded.

In most cases the presence of a tumor is the first evidence of the nature of the disease. This applies particularly to the renal tumors of children. The tumor, except when it develops in a movable kidney, occupies the lumbar region. Bulging in the lumbar region is unusual, the tendency of the growth being forward and downward. By bimanual exami-

nation relatively small tumors are discoverable. Frequently they are slightly mobile and are influenced by respiration.

Percussion yields a dull note, continuous to the spine, with the tympanitic resonance of the colon in front or to the inner side. Guyon first called attention to varicocele as a symptom of renal tumors. It is rapid in development and has been observed on both sides. Its occurrence after the fortieth year justifies the suspicion of a renal growth. It may be due to growth thrombosis of the left renal vein or of the vena cava, or to direct pressure from the tumor or infected retroperitoneal lymph-nodes. From pressure on or occlusion of the vena cava, edema of the lower extremities quite often occurs in the later periods of renal growths. The differential diagnosis as to the nature of a solid tumor is, as a rule, impossible. Rapidly growing tumors, particularly in children, are probably sarcomatous. Tumors of slow growth probably belong to the hypernephromata. For practical purposes a solid tumor of the kidney is malignant.

Treatment.—Treatment can consist only of nephrectomy. Contraindications to the operation exist in such fixation of the tumor as would render the operation exceedingly difficult, and with little prospect of a permanent result and the presence of metastases. The long bones must be particularly examined into, and, as Israel has pointed out, vague rheumatic pains must be regarded with suspicion of an existing metastasis.

In cancers of the kidney, as of other organs, early diagnosis while the tumor is still relatively small will justify nephrectomy. The sarcomata too of young children, which for a time presented a very high mortality after operation, justify a nephrectomy.

A nephrectomy may be performed by a lumbar or transperitoneal incision. Whenever feasible, the former should be given the preference; although when the tumor projects far forward and becomes an intra-abdominal growth, the lumbar incision can be carried forward quite to the rectus, whereby ample room is afforded. By the lumbar operation, when the tumor is large, it can be removed piecemeal, although whenever possible this should be avoided. Tuffier in such a case firmly tied a catheter about the lower half of the tumor and removed it with the thermocautery. The upper portion of the tumor could then be removed very easily. When large tumors must be removed by the abdominal incision, hemorrhage can be reduced to a minimum by the tying or clamping off of the renal vessels before the enucleation of the tumor mass is begun. In tumors, particularly removed by the lumbar route, when it is difficult to apply a ligature to the pedicle, a clamp may be allowed to remain with safety for a number of days.

The mortality of nephrectomy for malignant disease has been greatly reduced. Küster places it at about 25 per cent. Schmieden found that one hundred and eight out of three hundred and twenty-nine patients, or 32 per cent., died after the operation. According to decades in the history of renal surgery, the mortality has been reduced from 64½ per cent. in the first decade to 22 per cent. in the third. Even in young children the mortality of nephrectomy for sarcoma is being greatly reduced. Abbe has reported two successful operations, the cases living one and a half years

PLATE VI.

HYPERNEPHROMA.

after and continuing in good health; and I have one in which two and a half years have passed since the operation was performed. Probably the best results hitherto obtained are those of Israel, who out of forty-three nephrectomies lost but eight. According to Wagner, permanent cures, of from two to eighteen years, have been recorded in thirty-four cases. Twenty-one cases, according to him, have passed the three-year limit.

Benign Tumors.—Benign tumors of the kidney are very rare, forming, according to Morris, only 6 per cent. of renal growths. They have been of all the varieties of the connective-tissue group. The fibromata and lipomata predominate, but myomata, chondromata, and osteomata of the kidney have been observed. In very rare cases adenomata have been described. Most benign tumors of the kidney run a latent course until, by their size, they produce symptoms. Hematuria is very unusual. The diagnosis of these tumors presents such difficulties that in most cases it was not made until operation. The treatment of benign tumors of the kidney consists of nephrectomy. In a number of cases resection of the kidney has been practised with success. In view of the enormous preponderance of malignant over benign tumors, and the uncertainty which must always obtain regarding the diagnosis, nephrectomy must be the routine operation for all growths of the kidney.

Tumors of the Pelvis of the Kidney.—Of sixty-eight cases of renal tumors observed by Israel, two only were of the renal pelvis. Additional cases have since been recorded and collected by Albarran; Pelslueden reports two other cases. The tumors are most frequently papillomata of epithelial origin. The remaining tumors were either rhabdomyomata or sarcomata. Most of these tumors occurred in the fourth or fifth decades. The symptoms are those of malignant renal tumors in general, with what Israel believes to be a characteristic symptom, an intermittent hydronephrosis or hematonephrosis. The treatment consists of nephrectomy, with removal of as much of the ureter as possible, since the papillomata particularly have a tendency to grow downward.

Aneurism of the Renal Artery.—Of this rare condition Morris has given abstracts of nineteen cases. It occurs as a result of injury, and assumes either the sacciform or the diffuse type. In most cases the aneurism resulted from an injury, often of seemingly slight moment, and with or without discernible injury to the kidney. Of the nineteen cases, twelve were traumatic and seven spontaneous. The results of aneurism on the kidney are atrophy of more or less of the gland, either by pressure from without or from within the pelvis by distention. The matting together of the structures adjacent to the aneurism makes the differentiation of anatomic structures often difficult, if not impossible. As the aneurism grows it causes displacement, as do tumors of the kidney proper. Death results from hemorrhage.

Symptoms.—In four out of twelve cases abstracted by Keen the aneurism produced no symptoms, and was discovered at the necropsy. A tumor is the first symptom in most of the cases discovered during life. It has been found, as a rule, smooth and elastic, and of rapid growth.

The diagnosis has rarely been made before operation. On account of the small size of the renal artery as compared with the sac, pulsation has very rarely been observed, and auscultation has been negative. Hematuria is a most important symptom, although it is absent unless the aneurism communicates with the renal pelvis. In some cases the hemorrhage rapidly becomes fatal. A positive diagnosis has been made in only one case before operation. The treatment consists of nephrectomy. In most cases the operation will be exploratory for a supposed tumor of the kidney. If the incision reveals the aneurismal nature of the tumor by the presence of laminated blood-clots, it is best to check the hemorrhage by suturing the wound in the sac or by packing, then to follow the advice of Morris, to made a transperitoneal operation by opening the abdomen in front. The renal artery can in this way be secured before treating the aneurismal sac and removing the kidney. Four cases have been operated upon: three of them successfully by Albert, Hahn, and Keen. Morris had one unsuccessful case.

INJURIES AND DISEASES OF THE URETER.

Injuries of the Ureter.—These may be divided into the subparietal, the penetrating, and those resulting in the course of surgical operations. Wounds of the ureter of subcutaneous nature, except those involving the upper portion and extending into the pelvis of the kidney or the kidney proper, are exceedingly rare. Morris could collect only twenty-four supposed cases, of which he says that only three were actually proved to be ruptures of the ureter. In most of the remaining cases a lumbar swelling or a hydronephrosis gave rise to the diagnosis. In some of the cases many years elapsed between the supposed injury of the ureter and the formation of a tumor.

The injuries have for the most part been severe contusions, by which the ureter, usually at its upper portion, was forced against the transverse process of a lumbar vertebra. It may be that excessive stretching of the ureter may cause it to give way. The peritoneum does not ordinarily participate in the tear. The injury has occurred oftenest in the earlier decades.

Penetrating and perforating wounds of the ureter have been recorded a few times in military annals. They have resulted from stabs and gunshot injuries. In most of them concomitant injuries to other abdominal viscera were present.

Symptoms.—The urinary symptoms of rupture of the ureter are very uncertain. Hematuria, if present at all, is apt to be slight and transient. The quantity of urine may be considerably decreased. The chief symptom of rupture of the ureter is a tumor, diffuse in character, clearly fluctuating and evidently retroperitoneal. The shape of the tumor may be that of a hydronephrotic kidney. The nature of the rupture, whether it is slight or complete, will determine the rapidity with which this tumor manifests itself. Even when there is a complete tear, an inrolling of the ureteral mucosa may prevent rapid urinary exudation. As a result of shock or

reflex anuria from ureteral obstruction, the formation of the tumor may also be delayed. If the tear is a small one and the urinary exudation therefore slow, this may become inclosed by a thick wall and produce the condition of pseudo-hydronephrosis. If infection occurs, as it has in a considerable proportion of cases, it may lead to sloughing and the establishment of a ureteral fistula. As the result of an incomplete tear, stricture of the ureter may result, with the establishment, often after a number of years, of a hydronephrosis. In a few cases extravasation within the peritoneal cavity has occurred, and in them the characteristic tumor was absent.

The **diagnosis** of rupture of the ureter without ureteral catheterization cannot be positively made, since rupture of the kidney, and particularly of the pelvis, may produce similar symptoms.

The **treatment,** if the diagnosis could be made, would be the exposure of the ureter by a long lumbar incision, and the closure of the tear in the ureter as after ureterotomy for stone, or, in case of complete division, the lateral implantation of the proximal end. In most cases, however, the surgeon must content himself with the opening of the retroperitoneal swelling through a long incision, and the recorded cases show that this has hitherto been done at so late a period that the finding of the ureteral tear was impossible. Where plastic operations fail, nephrectomy may be required for the relief of a permanent fistula.

Wounds of the ureter from surgical operation, other than those intended for the removal of a stone or some plastic procedure, result mostly from pelvic operations, in which the uterus or adherent appendages are removed. Allied thereto are the ureteral fistulas, which remain after severe parturition with long compression of the soft parts and subsequent sloughing. In abdomino-pelvic operations the injury to the ureter may be discovered at the time of the operation, or it may not make itself manifest until some time thereafter. The catheterization of the ureters, as practised by Pawlik, Kelly, and others, reduces to a minimum the danger of injuring the ureters. Nevertheless, in consequence of mass ligatures or of using the thermocautery, sloughing of the ureteral wall may result and give rise to a fistula.

Symptoms.—An operative wound of the ureter may make itself manifest at once to inspection or later by the establishment of a ureteral fistula. This may show itself in the vagina, in the uterus, or in the abdominal incision. If the wound is not recognized at once, it may be difficult, after the establishment of the fistula, to determine the side of the injury. Cystoscopic examination will probably solve the problem. Vaginal ureteral fistulas not infrequently heal spontaneously after the lapse of a number of weeks. Other fistulas, as a rule, continue to discharge, and unfortunately often become infected and give rise to ascending ureteritis, and ultimately to pyelonephritis.

The **treatment** of a surgical wound of the ureter depends upon the time at which it is discovered. If it is seen at the time of the operation and is slight, a suture should at once be applied, as is sometimes done after ureterolithotomy. For transverse divisions, it is best to graft the upper

end into the bladder at once. Since the wound in most cases is near the floor of the pelvis, this would be practicable in most instances. Where neither of these plans is feasible, the proximal end may have to be fastened in the abdominal wound with the view to a secondary nephrectomy. The best method is that of vesical implantation. In a very considerable proportion of cases all conservative methods will fail and make a nephrectomy necessary for the cure of the fistula.

Ureteritis and Peri-ureteritis.—Primary inflammations of the ureter are exceedingly rare. A few cases have been recorded by Israel, White, and others. Usually the disease extends upward from the bladder or downward from the kidney. The ascending variety occurs oftener than the descending. It follows microbic infection of the bladder and has often been demonstrated to be of gonorrheal nature. Deformity of the base of the bladder from urethral stricture or prostatic disease predisposes to it. Descending ureteritis is often associated with tuberculosis.

The effect of infection on the ureter varies greatly. Frequently mechanical changes result in obstruction, and dilatation of the ureter above may result. This dilatation is often very irregular. Suppurative inflammation in the walls of such dilated ureters and peri-ureteritis are prone to occur. In other, and particularly chronic, cases, the ureter may be very much thickened, with irregularities of the lumen and great thickening of the peri-ureteral tissues. Stricture and valve formation are not unusual in this type. Saccular dilatations of limited length may result from them. Ureteritis, although secondary to bladder and kidney disease, may persist after the relief of the former or the removal of the affected kidney. Ureteritis and peri-ureteritis often cause the continuance of a purulent discharge from a fistula after nephrectomy.

Symptoms.—The symptoms of inflammation of the ureter are always grafted upon those caused by pre-existing disease of the bladder or other pelvic organs or of the kidney. Ureteritis may then be suspected when radiating ureteral pains are complained of, or there is a dull constant pain over the pelvic brim. Deep palpation may elicit tenderness, and in thin subjects make the recognition of the enlarged and tender ureter possible. Rectal and particularly vaginal examinations are often helpful by eliciting tenderness. Ureteral catheterization has in a number of cases established the diagnosis. In exceptional cases peri-ureteral suppuration may give rise to abscesses, which, whether they open spontaneously or are opened, may leave a ureteral fistula.

The **treatment** of ureteritis is in most cases prophylactic. When the disease has already developed and is not associated with an incurable disease of the bladder or ureter, some very excellent results may be achieved by ureteral irrigation. In the descending form of the disease drainage of the kidney or eventually nephrectomy may be needed to cure the ureteral infection. As already stated, this radical measure may fail, and the necessity arise for removing the ureter by a later operation.

Stone in the Ureter.—Stones in the ureter are of more frequent occurrence than was believed before our methods of diagnosis were per-

fected. Leonard believes that in cases not operated upon ureteral calculi often exceed the renal in the proportion of two to one, and in a slightly lower proportion in operated cases. In its descent from the bladder a stone is prone to be arrested about two inches from the pelvis of the kidney, at the brim of the pelvis or just above the ureteral orifice. Morris in forty-four cases found it nineteen times at the upper constriction, at the pelvic brim in ten, and near the ureteral orifice in fifteen. Bovee collected sixty-four extraperitoneal operations that bear out this proportion. A stone impacted in the ureter may remain for a long time. Young reports a case of probably twenty-seven years' duration. Ureteral calculi

FIG. 129.—STONES IN PELVIS OF KIDNEY AND URETER; THE LOWEST WAS REMOVED PER VAGINAM.

are usually single, but may be multiple. As in one of my cases, from which the accompanying skiagram was taken (Fig. 129), the entire ureter was filled with large stones. As a rule, stones are oval or oblong, and vary greatly in size. Very rarely the stone shows a groove by which retention symptoms may be prevented. In some cases a stone impacted in the ureteral orifice projects into the bladder.

Symptoms.—Ureteral calculi, except when in the lower end of the ureter, present no distinctive symptoms. Negative operations on the kidney for stone, if followed by catheterization, sometimes reveal a stone in the ureter. Sometimes, after most thorough exploration of the kidney, a stone in the ureter will subsequently be passed. The persistence of the

attacks of colic, the writer believes, speaks for ureteral rather than renal stone. Occasionally a distinct point of tenderness in the course of the ureter may be found. When the stone is lodged in the lower ureter, the vesical symptoms predominate even before the stone has entered the bladder. Ureteral catheterization, if feasible, with a wax-tipped bougie is the best evidence of a ureteral stone. A positive skiagram is excellent evidence, although, as stated in a former section, errors can easily arise. Stones in the lower part of the ureter can, not infrequently, be felt through the vagina or the rectum. As a routine practice in laparotomy, wherever feasible, palpation of the ureter should be carried as far as possible for the detection of calculi.

The prognosis of stone in the ureter largely depends upon its effect on the kidney. If the obstruction is sudden and complete, atrophy of the kidney, often without previous dilatation, will result. If the impaction is intermittent, an intermittent hydronephrosis has often been observed. Most depends, of course, upon the condition of the other kidney. The sudden impaction of a calculus is the most common cause of anuria. A stone weighing but a grain and a half has been known to cause death. Sometimes, in the absence of disease on the other side, the sudden impaction of a calculus may cause a reflex fatal anuria, as after a nephrectomy when the opposite kidney is found normal in every way. The prognosis of ureteral stone in the absence of anuria, when it is most grave, varies according to the rapidity with which the stone passes, the pressure effects produced by it upon the ureteral wall, and eventually on the peri-ureteral tissues. A stone may be impacted in the ureter for many years or may become fatal in a few days by inducing anuria.

Treatment.—That ureteral calculi may be passed safely is unquestionable. Cabot believes in the efficacy of massage in advancing the stone. When symptoms recur frequently or continuous pyuria indicates the danger to the kidney, and, of course, when anuria exists, an operation for the removal of the stone is indicated. Deaver lately collected twenty-five operations for ureteral stone with two deaths. In calculous anuria the operation should not be delayed more than forty-eight hours, lest the functional restoration of the kidney be impaired. Recoveries have ensued, of course, after anurias of seven days' standing, but these are exceptional. Calculous anuria left to itself, according to Legue, has a mortality of 73 per cent., whereas operation reduces it to 33 per cent. Since these statistics have been published, the post-operative results have been very much improved.

Stones found in the upper part of the ureter during an operation for kidney stone may, by manipulation, be brought into the kidney wound. For all other stones of the ureter, except those in the very lowest segments, the retroperitoneal operation is to be selected. Even for them successful extraperitoneal operations have recently been done. Young reports a number of cases thus operated upon. The perineal and sacral routes, which have recently been advised for the removal of stones low down in the ureter, are not to be commended. If the stone is very near the bladder, it can be removed by suprapubic section in the male or through

the vagina in the female. In the latter intravesical operations may be done through the dilated urethra. Intra-ureteral forceps have been devised by Lewis, but the range of their utility must always be narrow.

Stones in the remaining portion of the ureter can be removed by the retroperitoneal operation to be described later. In a number of cases it has been necessary to make an exploratory laparotomy to locate the stone. When the stone has been exposed by the retroperitoneal route and cannot be dislodged, the ureter must be incised longitudinally. After the removal of the stone a double row of sutures may be used, one for the mucosa, of catgut, and another for the outer tunics. But even if sutures are not employed, the wound in the ureter usually closes after a short time. Fiori (quoted by Deaver) incised the ureter for over six inches, removing twelve small stones. A permanent union was soon established. In every ureteral operation drainage must be employed.

With the certainty with which radiography locates stones in the kidney, it is no longer necessary, as was formerly the case, to explore the kidney by incision in uretero-lithotomy. The sounding of the pelvis of the kidney from the ureteral wound must not be neglected.

Tumors of the Ureter.—Primary tumors of the ureter are exceedingly rare. Those of the pelvis of the kidney, notably of the papillomatous type, have a tendency to invade the ureter. According to Albarran, who collected forty-two cases, those from renal descent were twice as numerous as the primary ureteral growths. The tumors have been of various kinds. Papillomata are perhaps the most common. Minute cysts have been found upon the mucosa of both ureters, and larger cysts related to the exterior of the tube, but connected with the lumen by a fine channel. Eccentric cyst dilatation of the intravesical portion of the ureter has also been encountered.

Primary malignant disease has rarely been observed. Metcalf and Safford were enabled to collect only seven cases. Tumors of the ureter in a large proportion of cases are associated with stone.

The **etiology** of ureteral tumors is unknown. The symptoms are those of tumors of the kidney, notably, hematuria, pain, and the presence of a tumor. In some of the cases the pain has largely been sacral. The hematuria, to be diagnostic, must be dissociated from pyuria, and even then the diagnosis is doubtful as to whether the tumor is in the ureter or in the kidney. If cystoscopic examination reveals a prolapse of a tumor mass through the orifice, or if with renal symptoms ureteral catheterization yields an obstruction, the detection of even a slight induration in the course of the ureter may warrant a diagnosis of ureteral tumor. In most cases, doubtless, the kidney will be first suspected.

Treatment.—Tumors of the ureter have been so rarely operated upon that the treatment must be based upon general principles. In most cases the diagnosis will be made or confirmed only at operation. In extensive disease, the other kidney permitting, nephrectomy with resection of the ureter must be done. In diseases of the lower end, resection of this with vesical implantation of the upper end is the plan to be pursued. In case the bladder is involved, its resection with the lower end of the ureter may be done through a suprapubic section.

OPERATIONS ON THE KIDNEY AND URETER.

Exposing the Kidney.—For the purpose of exploration, incision, fixation, or removal, the kidney may be reached, first, through

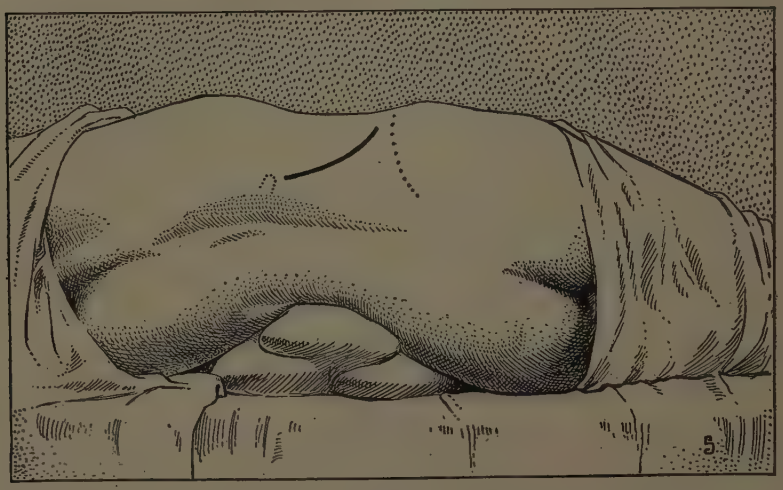


FIG. 130.—ORDINARY EXPLORATORY LOIN INCISION FOR EXPOSING THE KIDNEY (Greene and Brooks).

the lumbar or extraperitoneal route; second, through the abdominal or transperitoneal; and third, through the mixed route, by which, if need

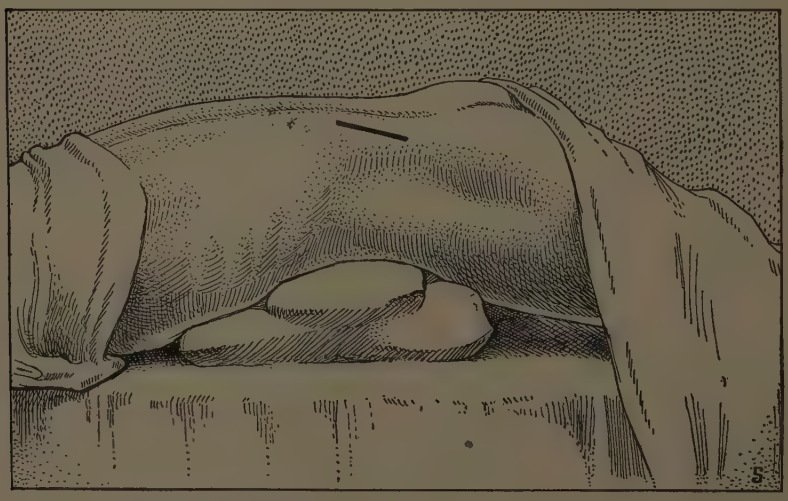


FIG. 131.—EDEBOHLS' INCISION FOR EXPOSING THE KIDNEY (Greene and Brooks).

be, the peritoneum is open. The normal method is the lumbar one.

For this purpose the patient is placed upon the sound side, slightly inclined forward, with the costo-iliac space of the sound side elevated as much as possible by sand-bags or preferably by the rest shelf of Cunningham's operating table. Some operators, following the lead of Edebohls, place the patient in abdominal decubitus upon an inflated air-cushion.

1. For exposing the kidney the **lumbar incision** is either vertical or oblique. The latter is the one most frequently used (Figs. 130, 131).

Beginning near the center of the last rib, at the outer edge of the sacro-lumbar furrow, the incision descends obliquely forward toward the superior iliac spine, whence it is curved a little forward. This incision may be continued parallel to Poupart's ligament to any required length. After dividing the subcutaneous cellular layers, a division is made of the lower fibers of the latissimus in the upper part of the wound, and of the external and internal oblique and the transversalis in the lower part. Where a large wound is not needed, the "gridiron" method may be employed, the separation of the muscular fibers being made in their direction. When this is done, the hemorrhage is less severe, and the danger of hernia is reduced to a minimum; but where an extensive operation is to be made, the room thereby obtained may be insufficient.

The aponeurosis of the transversalis and its fascia are next divided in the line of the cutaneous incision. At the bottom of the wound there will probably be exposed the iliohypogastric or the ilio-inguinal nerve. The twelfth dorsal nerve with its accompanying artery may appear in the upper part of the wound. These nerves must be carefully avoided in the placing of ligatures, and later in suturing. Bleeding from the branches of the lumbar arteries, which is usually slight, must be arrested.

At this stage of the operation the perirenal fat usually bulges into the incision. If it does not, firm pressure by an assistant on the abdomen usually brings it into the wound. This perirenal fat is next to be divided with a knife or by blunt dissection, when the fat capsule proper of the kidney is exposed as a distinct second layer (see Anatomy, p. 183). The wound being now widely opened by retractors, the fat capsule is best seized quickly by two ring forceps and divided. By holding it up by two forceps the bluish colored kidney is quickly seen at the bottom of a sort of funnel formed by holding up the capsule. Enucleation is thereafter best accomplished by the fingers, care becomes essential when the hilum of the kidney is approached, lest the thin-walled veins be torn. If the kidney occupy a high position, the division of the fascia must be made quite to the last rib, the knife being guided by the fingers in the wound.

The kidney being thus denuded, can easily be brought into the wound, and unless there are firm adhesions, particularly about the hilum, its delivery is easy.

Inspection and palpation of the kidney and the upper part of the ureter

PROPERTY OF SURGICAL OFFICE NOT TO BE REMOVED

are now possible. The subsequent steps of the operation upon the kidney or ureter will depend upon the condition found.

In exposing the kidney in this way there are two dangers: one, the wounding of the peritoneum; the other, of incising the pleura. The first accident is easily discovered and remedied by sutures. For the removal of large tumors, the opening of the peritoneum may become necessary to afford room for manipulation.

In delivering the kidney, the inrush of air may make a beginner suspect a wound of the pleura. Except in congenital absence or unusual shortness of the last rib the pleura cannot easily be wounded.

2. The **abdominal route** to the kidney is either through the middle line or through the outer border of the rectus on the side of the kidney to be reached. On the left side, after the peritoneum has been opened, there will be encountered the descending colon, to the inner side of which the kidney can be felt, slightly movable behind the peritoneum. The pulsations of the renal vessels can usually be made out. On the right side the ascending colon is first exposed. It is more difficult to feel the kidney, and especially the ureter, concealed behind the colon and the cecum. The hand slipped under the liver to the outer side of the gall-bladder, unless adhesions prevent, readily brings the kidney to the touch. Incision to expose the kidney should always be made to the outer side of the colon, lest the wounding of the retroperitoneal vessels supplying the colon and their tying off be followed by gangrene of the gut.

3. The **mixed method of exposing the kidney** is by long vertical incision an inch or more to the outer side of the rectus. When the peritoneum is reached, it is pushed toward the middle line without being opened. If necessary for the removal of large tumors by this method, the peritoneum may be incised as far as need be. The advantage of this operation is in the room afforded. Some operators make altogether a transverse incision from the sacrolumbar mass to the right border of the rectus. Except for nephrectomy, and that for large tumors only, the lumbar route is the one to be selected as the normal one for reaching the kidney.

Nephropexy.—A vertical or oblique incision being made over the kidney, the fat capsule is exposed and drawn into the wound. Only when this is opened freely can the surface of the kidney be exposed. Pressure on the abdomen by an assistant facilitates the delivery of the kidney and its capsule into the wound. When the fat capsule is very loose, it is best to remove as much of it as possible from the posterior surface and often from the anterior. An important factor is to preserve the lower part of the capsule, which is in relation with the colon. When this, toward the close of the operation, is firmly drawn into and fixed near the upper angle of the fascial wound, it serves as a sling ligament to hold the kidney as on a shelf and in its normal oblique position. From this stage of the operation many methods of procedure are feasible.

In my hands the operation which has given the best results consists of splitting the capsule of the kidney along the convex border over its upper half. A transverse incision is then made in front and

behind, and two large quadrangular flaps are made, exposing from four to six square inches of the surface of the kidney. Through the upper flaps a chromicized catgut suture is passed, and with a flat, curved dull needle passed close to but above the last rib. The anterior and posterior flaps are then sewed by catgut sutures to the respective margins of the fascial wound. The lower part of the fat capsule is utilized as already stated. The wound is closed by buried sutures without drainage. Various modifications of utilizing the capsule have been practised. Strips may be passed through the muscle in various ways. Werelius has advised what he terms the "basket operation" (Fig. 132). A number of operators pass sutures through the kidney substance. Except where kidney fixation follows a nephrotomy, this practice ought not, in the judgment of the writer, be done.

Believing that granulation tissue forms a firmer scar than follows clean suturing, Senn advised the method of producing such granulation tissue by passing a strip of iodoform gauze above the kidney and a second packing about and below the kidney, with secondary sutures completing the operation.

Whatever operation is performed, rest in bed for at least from four to six weeks is to be enforced.

FIG. 132.—NEPHROPEXY, BASKET OPERATION (Werelius).

Capsule Splitting.—Allied to the operation of nephropexy is that of capsule splitting for the relief of certain forms of nephritis and of nephralgias that are intractable. The capsule is split along the convex border and stripped from the kidney to the hilum. In some cases it may be advisable, after the practice of Edebohls, to remove the capsule entirely.

Nephrotomy is the operation of incising the kidney for exploration or drainage, for the removal of stone, for the relief of unilateral nephralgias, or as preliminary to plastic operations for hydronephrosis or pyonephrosis. The incision into the kidney varies with the purpose of the operation. In every case, whether long or short, it should be made a little posterior to the convex border, hemorrhage being prevented by the fingers of an assistant, of the operator himself, or by a padded clamp, temporarily shutting off the blood-supply to the kidney. If the operation be done for suppuration or distention of any character, the incision may be made through the most fluctuating area, irrespective of its relation to the non-vascular zone. The final steps of a nephrotomy depend upon the

conditions found. If the kidney is aseptic, or in other conditions, even if natural drainage through the ureter is likely to take place, the kidney wound is closed with deep and superficial through-and-through sutures of catgut, which must be long enough to serve later for the anchoring of the kidney to the fascial wound margins.

If nephrotomy is done for suppuration, drainage by means of a large tube is indicated. When the distention with pus is marked and the justification for primary nephrectomy is insufficient, the cut surfaces of the kidney may be sewed to the fascial margins of the lumbar wound. The fistula thereby may eventually close, with the subsequent retraction of the kidney (nephrotresis).

Nephrolithotomy.—The preliminary operation is that of nephrotomy. When a stone can be felt in the pelvis, the incision may be made directly over it, and in the direction of the blood-vessels of the hilum. It is often best in these cases to incise the kidney rather than the pelvis, since incisions of the latter are followed by fistula very much oftener than follow incisions into the cortex. The proportion is about seven to one. The incision through the cortex along the line indicated should be only long enough at first to admit the finger into the pelvis. With the knowledge obtained as to number and character of stones by *x*-ray examinations, the nephrotomy wound is now rarely to be made very long. The stone can be removed with the finger, a scoop, or forceps. Wherever feasible, the ureter must be sounded quite to the bladder. Small stones in the pelvic outlet require special care lest in the manipulation for their removal they be pushed into the ureter. In aseptic nephrolithotomy the wound in the kidney or its pelvis is closed with sutures. For suppurative pyelitis with distention, drainage is required. Aseptic nephrolithotomy has a mortality of from 2 to 5 per cent. In suppurative cases the immediate mortality is 20 per cent. In forty-four operations which I collected five years ago, and in which a stone was not found, there was no death. I recently lost one patient from shock after nephrotomy for the relief of severe nephralgia, the cause of which the operation failed to reveal.

Nephrectomy.—The kidney may be removed through the lumbar, the abdominal, or combined incisions. Except for solid tumors of very great size, the lumbar route is the normal one.

The incision usually employed is the oblique incision already described for exploration of the kidneys, for kidney drainage, and nephrolithotomy. It should be of ample length. In rare cases a subperiosteal resection of the last rib, and even of the eleventh, may be necessary to afford sufficient room.

Following the recommendation of Koenig, some operators begin with a short vertical incision extending nearly to the iliac crest along the outer border of the erector mass. The lower end of the incision is directed transversely forward and continued to the outer border of the rectus All of the abdominal muscles are divided layer by layer, until the peritoneum is reached. This is pushed toward the midline without being opened. When the growth is a large one, the opening of the peritoneum may not

be avoided. While this incision gives very ample room, there is an unnecessary exposure after it to ventral hernia.

By whatever incision the kidney is exposed, it is next separated from its surroundings. In case of tuberculosis, cystic disease, and pyonephrosis, it must be shelled out from its fat capsule. In many cases where enucleation would otherwise be very difficult, the splitting of the fibrous capsule with subsequent decapsulation will greatly facilitate operation. When perirenal adhesions are extensive, enucleation of the kidney may be very difficult. It is better then to divide adhesions with a scissors than to tear through them by main force. A tear in the kidney at this stage of the operation, before the blood-supply is under control, may give rise to hemorrhage which may be excessive and greatly interfere with the rapid delivery of the kidney. Subcapsular nephrectomy, although occasionally unavoidable, should not be made the routine practice, since the wound repair after it is apt to be needlessly prolonged.

In malignant disease the nephrectomy should be made in a manner to include as much as possible of the surrounding fat capsule. It is in these cases that the wounding of the peritoneum and of the colon is especially to be guarded against. In the event of the former, the place of the tear should be accurately fixed to be closed at the end of the operation.

With the delivery of the kidney, a pedicle is naturally evolved. It consists of the structures entering the hilum, and the fat in which they are embedded. The management of the pedicle varies with its nature. If it is fairly long, light traction on the kidney will permit the easy recognition of the ureter, its separation from the blood-vessels, and its division between two ligatures. The vascular part of the pedicle is then best perforated with a blunt pedicle needle armed with a stout double thread. A Staffordshire knot firmly drawn home, when all tension on the pedicle has been withdrawn, firmly secures the renal vessels. The ligatures are kept long and the kidney removed with a few cuts of the curved scissors. The stump should always be carefully examined, and, if possible, the individual vessels tied separately. The ligatures first applied are then cut short. If the pedicle is short and adherent, as it is often in old-standing cases of tuberculosis and of calculous pyonephrosis, two curved clamps may be firmly placed upon the mass of the pedicle, one from above and the other from below. The kidney is removed close to the clamps. With a transfixation needle the pedicle may then be tied below them. In a number of cases presenting great difficulties the writer has permitted the clamps to remain. In one case a hemorrhage followed immediately on the removal of the clamp on the sixth day after the operation. Fortunately, by immediately enlarging the wound, the patient's life was saved.

Where the isolation of the ureter is possible, it may be left to take care of itself after being tied, provided there is no infection. In pus cases, and particularly in tuberculosis, as much of the ureter should be removed as possible; or if this is not feasible, its proximal end should be fixed in the lower part of the wound by a suture.

The removal of the kidney always leaves a large cavity, the drainage of which, at least for a few days, is to be recommended. Buried layer

sutures with catgut are then used to bring the parts divided as nearly as possible into their normal relations.

Partial nephrectomy may be practised in exceptional cases of rupture or of localized abscess. The preliminary steps of the operation are those of nephrectomy. After the bleeding is controlled by digital compression of the pedicle or the use of a catheter, the diseased part of the kidney is cut away in such a manner as to permit the suturing of the stump.

In some cases where it is impossible to remove the kidney as a whole on account of adhesions, Tuffier has, as a makeshift, recommended the taking away of the gland piecemeal (*en morcellement*). Portions of the exposed kidney are crushed between the blades of strong forceps and removed with the thermocautery. Piece by piece the gland may thus be removed until the making of a pedicle becomes comparatively easy.

Operations on the Ureter.—For purposes of repair, removing stones, or excision, the ureter can be exposed by either the retroperi-

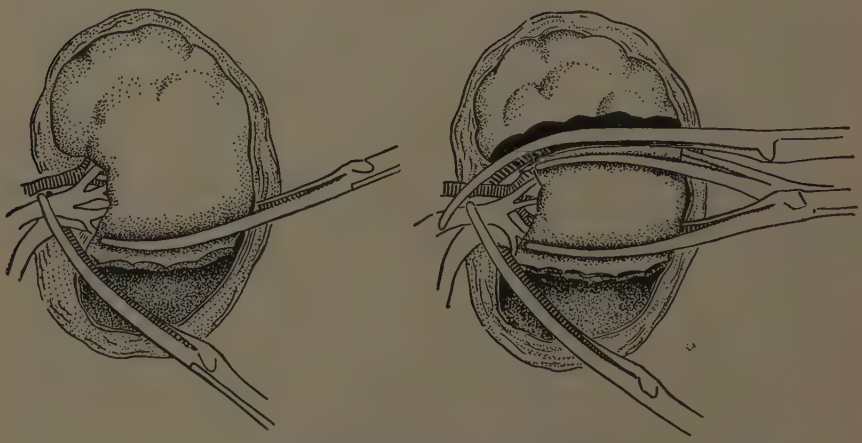


FIG. 133.—MORCELLEMENT OF KIDNEY (Tuffier).

toneal or transperitoneal route. Although this is possible for the entire length, the lower two inches may also be exposed by the vaginal route in women or the sacral or pre-rectal route in men. The latter procedure is rarely justifiable, and the former is applicable only to the removal of a stone or the excision of the lowermost ureteral segment.

When the seat or nature of the ureteral lesion is unknown, the exposure of the duct is best made by the retroperitoneal operation, which permits an examination of its entire length. A long lumbo-iliac incision is made, beginning below the last rib, as in the operation for exposing the kidney. In a gentle curve it is directed downward and forward an inch within the anterior superior process, and thence continued forward a little above Poupart's ligament, and parallel to it, quite to the border of the rectus. The dissection necessary to expose the ureter is but an extension downward of that for the kidney, the fact being borne in mind that the ureter adheres to the peritoneum when the latter is reflected

toward the median line. The crossing point of the ureter over the common iliac vessels is a landmark also to be remembered. When it is known that the lesion is situated in the pelvic segment, the incision may be limited to its lower part, beginning above, opposite the iliac spine, and ending below, near the rectus. The three muscular planes and the transversalis fascia are next divided, and the peritoneum with its subperitoneal fat reflected inward. The pulsations of the iliac artery are again an effectual guide to the ureter, which can, with a little traction, be traced quite to its vesical insertion.

The transperitoneal route is at present indicated only in lesions of the lower segment for repair operation and for digital exploration. The smallest stones found by the operator were located in this way and removed by lumbar incision. With the perfecting of radiography, an abdominal operation for locating a stone will rarely be called for. At present the transperitoneal operation should be reserved for vesical implantation of the proximal ureteral end in wounds inflicted during pelvic operations, and in strictures or valve formations low down with the same implantation in view. The operation consists of a median subumbilical laparotomy. After division of the posterior peritoneal layer, the ureter is sought by its relation to the pelvic brim and the iliac vessels. Its cord-like feel makes it easy of recognition. It may be found so distended as to have lost semblance to the normal ureter. However the ureter may be exposed, it should be separated as little as possible from the parts with which it is in relation, lest sloughing result. It is usually necessary to introduce a sound through a small longitudinal incision for exploration.

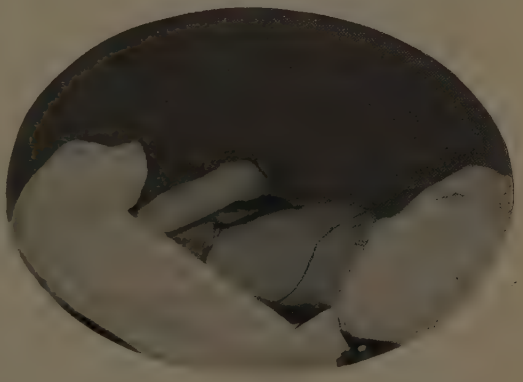


Fig. 134.—Long Incision to Expose Ureter.

Uretero-lithotomy.—The part of the ureter to be opened in this operation depends upon the position of the stone. In most cases it will be found in the suprapelvic portion, and the lumbar incision with or without nephrotomy will suffice. For the upper part of the intrapelvic portion, too, the extraperitoneal operation, already described, will be most serviceable. Only in impaction near the vesical orifice is the stone to be removed through a suprapubic section or through the vagina or by the perineal method. The transperitoneal removal of a stone is never justified, since the sterility of the urine cannot be depended upon. Even with careful suturing of the peritoneum over the ureteral incision, the danger of extravasation is very great. If a stone thus revealed cannot be dislodged, it must be removed then or later by retroperitoneal operation.

The incision in the ureter should always be in its axis, and rather above the site of impaction than through it. After the stone is removed, the ureter must be sounded in both directions to determine whether there are other stones. If a stricture is found, it must be divided or treated by the Heineke-Mikulicz plastic operation, or by ureteral anastomosis. Sutures may be employed, although without them the wound closes quickly. In wounds of the lower ureter, sutures, although most difficult of insertion, are nevertheless to be used.

Ureterorrhaphy—Uretero-anastomosis.—Partial wounds of the ureter may be closed by fine silk sutures placed with a round needle and including all of the structures to the mucosa. The needle should be introduced about an eighth of an inch from the wound margin. Complete division of the ureter may be treated by an end-to-end suture, its line being transverse, or, as first recommended by Bovee, to be made oblique with the object of preventing post-operative contraction. To support the ureter

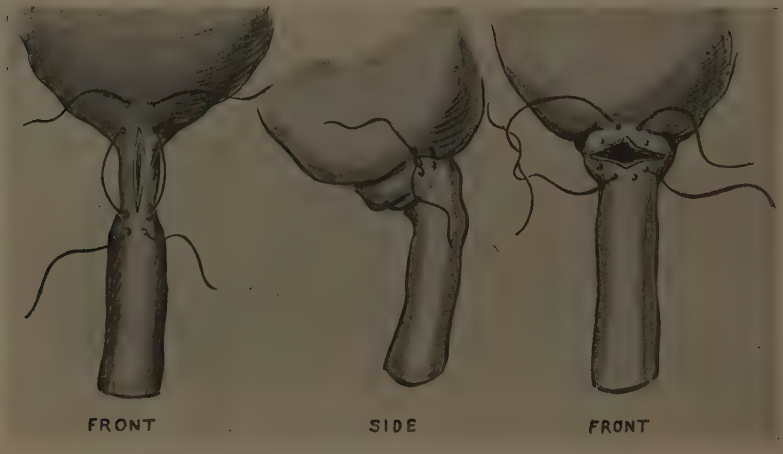


Fig. 135.—Plastic Operation for Stricture of Ureter.

during the process of suturing, a ureteral catheter or iodoform crayon may be used. Poggi, in 1887, and Markoe, ten years later, practised the invagination of the upper into the lower end of the divided ureter, or end-in-end anastomosis. The operation consists of dilating the vesical stump for a distance of half an inch or more. Then a catgut suture armed with a needle at each end is passed once through the renal end of the ureter and twice through the vesical, the latter from within out. A similar suture is then introduced on the opposite side. When these sutures are tightened, the upper end is naturally drawn into the lower. To facilitate the invagination, it may be necessary, as practised by Robson, to split the lower end until after the invagination has been completed.

Lateral Implantation.—This operation, first devised by Van Hook and developed in dogs, gave a great impetus to plastic operations on the ureter. For general purposes, it is still the operation of preference. It is begun by tying off the distal portion of the ureter a fourth of an inch from

its end. An incision twice as long as the ureteral diameter is next made in the axis of this segment, beginning a fourth of an inch below the ligature. To insure the patency of the ureter, the upper segment is next divided or notched for a little more than the fourth of an inch. The operation is completed by invaginating the upper into the slit of the lower segment by means of sutures somewhat like those described in the operation of Poggi. A second row of sutures may be used to strengthen the anastomosis. An operation of lateral ureteral anastomosis has been performed experimentally by Monari. It is the counterpart of the same operation on the intestine.

The choice of method must be made in the individual case, according to the condition found. The advantages of invagination and lateral implantation lie in the rapidity with which they can be performed. The supposed greater dangers of leakage and of contraction after the end-to-end anastomosis have been shown by Bovee not to exist.

Ureterectomy.—Excision of the ureter may be partial or complete; primary or secondary. The partial excision of a ureteral segment, with subsequent anastomosis and vesical or renal implantation, is properly termed resection. The chief indications for ureterectomy are tubercular and chronic ulceration of the ureters secondary to disease of the kidney. For strictures or valve formations where the methods considered under the treatment of hydronephrosis are not applicable, resection may be indicated. Primary ureterectomy, partial or complete, is usually done as a complement to nephrectomy by the extraperitoneal route. In some cases the operation has been performed by the transperitoneal method (Kelly). Secondary ureterectomy is, as a rule, performed for the relief of a persistent fistula; after nephrectomy for tuberculosis or pyonephrosis.

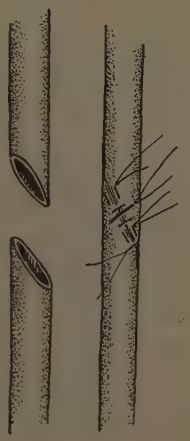


FIG. 136.—URETERO-ANASTOMOSIS.

Primary ureterectomy, complete or partial, is performed by the retroperitoneal route, the incision being carried downward and forward as already indicated. Whenever possible, the renal vessels are the first to be tied. The delivered kidney is then brought into the wound. Traction made upon it exposes the ureter. It is separated from the bed of connective tissue in relation with the peritoneum, and in partial ureterectomy is divided after being tied as low down as necessary. If the kidney cannot be decreased in size by incision, it may be necessary to remove the kidney after a mass ligature has been applied to the pedicle, before sufficient room for exposing the ureter can be obtained. The vesical stump should be treated as the stump after appendectomy, by cauterization or invagination.

The operation of nephro-ureterectomy at one sitting is a very severe one, and should not be performed unless the condition of the patient, as the operation progresses, warrants it.

A second ureterectomy may be performed when a fistula continues to discharge for a number of months, or when, from its appearance, it evidently is tuberculous. It is not wise to defer operation too long, since the peri-ureteral adhesions make the operation more difficult as time progresses.

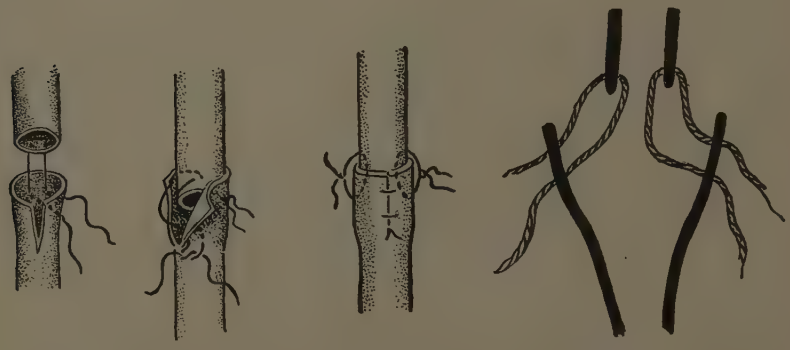


FIG. 137.—URETERO-ANASTOMOSIS, INVAGINATION METHOD.

After ureterectomy, as after nephrectomy, drainage of the wound is demanded.

In rare exceptions, because of adhesions in the pelvis, it may be necessary to combine the lumbo-abdominal operation with the vaginal incision for the removal of the lower end of the ureter. For this purpose Kelly made an opening into the vault of the vagina, guiding the scissors with

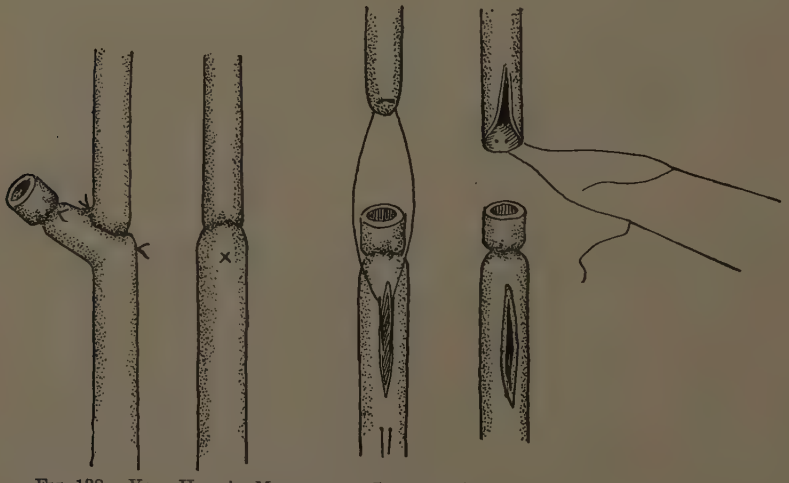


FIG. 138.—VAN HOOK'S METHOD OF LATERAL IMPLANTATION OF THE URETER.

which it was made with the fingers of the left hand pushed downward from the abdominal wound. With a pair of forceps introduced through the vaginal opening the stump of the ureter can be drawn through the vaginal opening and removed. In whatever way the lower segment of

the ureter is removed, there is danger of wounding the uterine artery in the female or the vas deferens in the male.

Ureteral Implantation.—When the course of the urine to the bladder is seriously impaired by stricture, fistula, wound of the ureter, or in case of exstrophy of the bladder, and in which the repair operations on the ureter already described have been unsuccessful or inapplicable, implantation of the proximal end of the ureter into the bladder, the renal pelvis, the opposite ureter, or the intestine may be resorted to. The ideal procedures are the implantation of the proximal end of the lower segment into the renal pelvis, as in hydronephrosis, and the fixation of the lower end into the bladder for wounds or strictures. As a makeshift, rarely to be employed, the ureter may be implanted into the vagina, the skin, or the intestine. In point of value, implantation into the bladder or into the renal pelvis comes first. In valve formations high up and in cases of

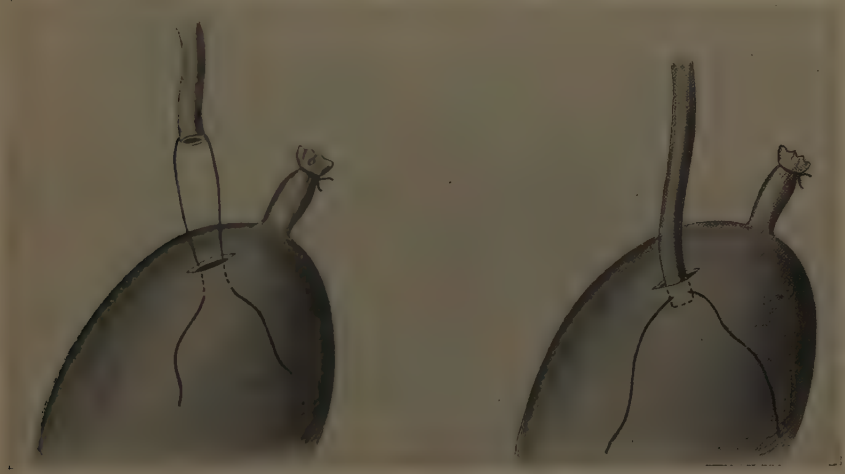


FIG. 139.—IMPLANTATION OF URETER INTO BLADDER.

hydronephrosis, implantation into the renal pelvis as already considered is one of the operations of choice. Where the length of the upper end of the ureter permits, vesical implantation or *ureterocystostomy* is to be performed. Where deficient length of the proximal ureteral end prevents this operation, it may, on experimental grounds, be implanted into the ureter of the sound side. The danger of such uretero-ureteral anastomosis from side to side, by reason of imperfect technic and the danger of leakage, may make the removal of the kidney the safer operation, the other kidney permitting.

Ureterocystostomy.—Fixing the ureter into the bladder is an operation with a large future, since it will probably supplant many of the ureteral repair operations for the pelvic portion. It is easier of accomplishment. It is best performed by median laparotomy after the bladder has been moderately distended. The ureter is next exposed at the pelvic brim. It is well now to pass a thread under it to make traction on the

duct. In this way the lower end of the ureter can be brought into view and the point of the bladder be determined where the implantation is to be made. The ureter at its lowest point is next exposed by a longitudinal incision through the peritoneum, a ligature being then passed around this point. The ureter is squarely divided after a padded clamp or temporary ligature has been placed on the proximal segment. A longitudinal cut may then be made, as in the operation of ureteral invagination, to secure a larger orifice. An incision is next made through the bladder, preferably on a metal sound (No. 12 F.), as near as may be to the ureteral end. It is to be made progressively smaller from the peritoneum, leaving it smallest at the mucosa.

Ureterovesical suture may next be made with the sound introduced into the ureter to steady the parts. Interrupted catgut sutures approxi-

FIG. 140.—VESICAL PLICATION AFTER URETERAL IMPLANTATION.

mating mucosa to mucosa are used. When the fixation has been accomplished, the peritoneum is carefully replaced and fixed by suture. The sewing of the ureter in the vesical wall can be more quickly accomplished by invaginating it into the vesical opening by means of catgut sutures passed through the ureter, through the vesical opening, and out through the bladder wall near the margin of the opening in the bladder. When the sutures are tightened, the ureter is drawn into the bladder. To secure the fixation, plication of the bladder wall may be made as in the Witzel operation of gastrostomy. If the ureter is too short for implantation and excessive traction would endanger its circulation, the bladder may be displaced upward by separating its attachments to the pubic arch. Mechanical devices have been introduced to facilitate the operation. The button of Boari and the tube of Chalot are among them. They have little to recommend them.

Uretero-enterostomy—Implantation Into the Bowel.—As a resort, rarely to be employed, the ureter of one or both sides may be implanted into any portion of the intestine. The sigmoid flexure has most frequently been selected. But the ascending or descending colon may be used. The technical difficulties of the operation are few, but the danger from ascending infection of the kidney is very great. The operation has been done most frequently for the relief of exstrophy of the bladder. The operation consists of the transperitoneal exposure of the ureter, the division of this as low down as need be, and the ligation of the distal end. The proximal end is next brought in contact with the internal surface, preferably of the colon, and is fixed there by a number of sutures. The implantation into the intestine is completed as in the operation of vesical

FIG. 141.—URETERO-ENTEROSTOMY.

implantation. To prevent infection, axial implantation has been recommended by Martin, whereby an inch or more of the ureter is buried in the wall of the intestine. Fowler accomplishes the same end by establishing a permanent valve of intestinal mucosa, which covers the open mouths of the ureters. He also places the ureters for a distance of an inch or more in the submucous space of the rectal wall, thereby affording an additional safeguard against infection.

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SURGERY OF THE SUPRARENAL OR ADRENAL GLANDS.

Anatomy.—The suprarenal glands, as their name implies, cap the upper poles of the kidneys more on their anterior than on their posterior surfaces. Behind they rest on the crura of the diaphragm, the right one on a slightly higher level than the left. The right suprarenal is pyramidal, the left, semilunar, in shape. They are both retroperitoneal. The right suprarenal is in relationship above with the liver, forming a well-marked depression. Its inner border is in contact with the ascending vena cava. The left is in relationship with the pancreas and spleen, forming a portion of the bursa omentalis. The gland on section is seen to consist of two parts, cortex and medulla, the cortex forming the greater part. The cortex is particularly rich in a substance known as protagon, which has the same staining reactions as fat, differing from it, however, in having a double refraction for reflected light. The medulla is formed principally of chromophilic cells derived from the sympathetic system. The blood-supply is copious from three sources—the aorta, the renal, and the phrenic. The nerve plexus is exceedingly rich, derived from the pneumogastric and splanchnics through the solar, celiac, and renal plexuses.

Congenital absence of the suprarenals has not been described, although one or both may be exceedingly small, in which case their function is partly relegated to the sympathetic. The functions of the suprarenals, as Crile and others have shown, is to control the tone of the vascular system by central action on the vasomotor center, and peripheral action on the arterioles.

Tuberculosis is the most common disease affecting the suprarenal grands. In common with other affections of these glands, it gives rise to the symptom-complex well known as Addison's disease. The principal symptoms are great weakness and emaciation and a severe anemia of the secondary type. The attending symptoms of anemia, palpitation of the heart, anemic murmurs, and dyspnea are, of course, present. Severe gastro-intestinal symptoms, hematemesis, and melena

are almost invariably a feature of the disease. The bronzing of the skin described by Addison as typical of the condition is frequently absent.

Treatment.—Though not, as a rule, considered amenable to surgical intervention, several cases of operation for tuberculosis of the suprarenal have been reported. Jonas, Helferich, and Heinheim have reported successful cases. In Jonas' case the well-marked bronzing of the skin disappeared three weeks after operation.

Suprarenal abscesses, of both traumatic and tuberculous origin, have been reported, but the cases are rare. Embolic abscesses occur in the course of general septicopyemia, but do not come within the realm of surgical intervention. The symptoms are those of septic infection plus the localizing symptoms of pain and tenderness in the epigastric and lumbar regions. Heinheim has recently reported abscess of the suprarenal successfully opened and drained. If possible, the operation should be done extraperitoneally.

Tumors of the suprarenal, although not common, are occasionally seen; more often on the post-mortem table than in the operating room. The benign tumors most frequently seen are adenomata and cystadenomata. These cysts may reach a very large size. The cyst wall may be formed by the cortex of the gland.

Cysts offer the most favorable prognosis for surgical intervention. Many cases have been successfully operated on. Among these are the cases of Donald, Pawlik, and McCosh. Bier operated on a large blood-cyst; the outcome, however, was fatal.

The small adenomata and encapsulated hypernephromata give rise to no symptoms. Sarcoma, the most frequent malignant tumor of the suprarenal, is encountered in all its varieties. Malignant hypernephromata are not uncommon and show the same characteristics and metastases as those occurring in the kidney. Securian reports a very interesting and rare case of myosarcoma operated on with good results. Shilling reports a case of endothelioma. Carcinoma is at times seen. A most interesting suprarenal tumor is the glioma, very malignant and prolific of metastases. According to Küster, these neoplasms are formed from rests of the sympathetic cells, which in embryonic life have formed the medulla of the sympathetic glands. Histologically, they have the properties and the same reactions as the ordinary glioma. They are very malignant, growing with great rapidity and giving rise to early and plentiful metastases. The vena cava and other large veins are soon involved in the growth.

The **symptoms** of suprarenal tumor are exceedingly obscure, making an early diagnosis difficult and at times impossible. Attention may be called to the tumor by metastases before localizing symptoms have occurred. When bronzing of the skin is present, the diagnosis is, of course, simplified. Unfortunately, this symptom is very variable, only occurring in a small percentage of cases.

Holt reports a case of double suprarenal tumor—one of sarcoma, one of carcinoma—without bronzing the skin. Israel has pointed out the similarity between renal and suprarenal tumors. The suprarenal tumors

are even at times attended by hematuria, due to the congestion of the kidney from pressure on the vena cava and renal veins. One distinguishing symptom is the early, severe, and constant pain in the territory of the lumbar nerves from the pressure of the growing neoplasm. If stone in the kidney can be ruled out by *x*-ray, with no tumor evident in the lumbar region, the presence of suprarenal tumor is very likely. The suprarenal tumor differs in position from the renal tumor. When felt at all, it appears in the epigastric region, while the lower pole of the downward dislocated kidney is apparent below the ribs. In these cases the diagnosis may be made with some degree of accuracy.

Surgical procedures in tumors of the suprarenal have hitherto not been attended by brilliant results. The reasons are manifold. The diagnosis is often not made before the growth has become wide-spread. In other cases the tumor has given rise to plentiful metastases before localizing symptoms have appeared. Owing to the inaccessibility of the region and the proximity of the great vessels, the operation is attended by great difficulty. Israel concludes from his personal experience that the prognosis is extremely bad. Most of the cases operated on die from the immediate effects of the operation. In those cases which recover from the operation an early recurrence is almost invariable. Three of Israel's cases, Küster's, Finney's, Nicoladoni's, and one of Morris's cases died immediately after operation. Mayo Robson's case survived the operation one month, Gussenbauer's three months. Morris's case of hypernephroma lived eight months and Shilling's endothelioma succumbed after one year. Kelly reports a case of fibromyxosarcoma as cured; how long after operation is not known.

The operation may be done either by the abdominal or lumbar route. The most favorable incision is one extending along the lower border of the twelfth rib and forward into the epigastric region. In all cases the operation, if possible, should be extraperitoneal. Owing to its involvement or position, the kidney must in some cases be removed. The vena cava has been resected.

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CHAPTER LVII.

SURGERY OF THE BLADDER.

By Bransford Lewis, B.S., M.D.,
ST. LOUIS.

DIAGNOSIS OF GENITO-URINARY DISEASES.

General Remarks.—The two steps necessary in arriving at a diagnosis of disease are: (1) acquiring the evidence referable to the affection; and (2) reaching correct deductions from that evidence.

By some the chief part of this program is considered to be the eliciting of an elaborate and systematic history of the case, with the collection of all side-lights, observations, and impressions of the patient. The French have been especially diligent in developing the symptomatology of disease and bringing to bear on it able scientific analysis. The modern trend, however, seems to be away from this direction, placing greater reliance on the numerous direct methods of examination that have come into vogue. With these at one's disposal, it is probable that the diagnostician can, in a few minutes of investigation, acquire more definite and material information than he can with hours of research into a case-history.

There are reasons for this, aside from the materialistic bent of modern practice. The prominent symptoms of urinary affections, while strongly indicative of disease at certain points, are not efficient for differentiating between the several forms or kinds of disease that may affect those parts. It is a common thing for patients afflicted with urinary diseases to relate their troubles to one another, with the unvarying conclusion that they are suffering from the same complaint, basing it on the common symptom, for instance, of frequent urination; whereas the one may be affected with tuberculous cystitis, the second with urethral stricture, and a third with renal disorder—totally different affections in their pathologic basis. Furthermore, investigators are not now satisfied with the simpler diagnosis formerly sought for. A diagnosis of "urethritis" does not suffice: one must learn whether—(*a*) the infection is from gonococci or other organisms; (*b*) what part or parts of the urethra are affected; (*c*) what complications or extensions of the infection exist. With reference to prostatic hypertrophy, one must learn—(*a*) if there *is* hypertrophy present; (*b*) if it is causing obstruction to urination; (*c*) the measure of such obstruction; (*d*) the actual form of the prostatic outgrowth or enlargement that is causing the obstruction; and (*e*) the condition of the other urinary organs, especially the kidneys. Symptomatology makes none of these differentiations; they must be determined by refined methods of physical examination.

Special Methods of Investigation.—In carrying out the steps of physical examination, certain routine methods should be applied. In a person complaining of some urinary trouble, after the history is obtained and recorded (under some systematized and approved plan), the patient is required to remove coat and vest, to lower trousers and drawers, presenting a full and unobstructed view of the external genitals, and without preliminary cleaning or altering of the local conditions. Inspection of the prepuce, the glans penis, and of the meatus is then had, with, finally, pressure along the urethra to express any possible content through the meatus. In case there is discharge (pus), three specimens of it are smeared on glass slides, for staining and microscopic investigation. Before any instrumentation or other procedure is undertaken, the patient is next requested to urinate into two glasses, the first part into glass No. 1, and the second part into glass No. 2, if possible reserving an ounce or so in the bladder for subsequent passage into a third glass. The two urines just passed are inspected and records are made as to the cloudiness of either or both, as to whether they contain shreds or flocculi, and what the cloudiness is caused by (whether pus, bacteria, spermatozoa, precipitated phosphates or urates, or blood-corpuscles). While the urines are undergoing sedimentation to determine these points, the patient is made to bend over a chair, with his hands resting on its seat. Armed with a rubber finger-cot well lubricated with one of the Iceland-moss or tragacanth lubricants, the forefinger of the operator is gently introduced into the rectum, palmar surface downward, and the prostate and the seminal vesicles are palpated and subsequently stripped or massaged, their size, tenderness, and other conditions being determined at the same time. Drops of mucus or pus oozing from the meatus as a result of these manipulations are caught on a sterile butter-platter, for microscopic investigation, stained and unstained. If no drops appear at the meatus, one is still able to obtain the products expressed from the prostate and vesicles by having the patient pass the small remaining portion of urine into the third glass; which is also examined by means of centrifuge and microscope.

The patient is now ready for instrumental examination. If such a step had, however, preceded the ones just described, the products obtained from the urine, the urethra, prostate, and vesicles would have been modified by the instrumentation itself, leading to fallacious conclusions.

The instruments now selected for examining depend on the object of the search. They may be bulb-sounds for the purpose of discovering stricture, or endoscopes for localizing urethral evidences, or the stone searcher for detecting calculus, a soft-rubber catheter for measuring the amount of residual urine present, or the cystoscope for inspection of the bladder or differentiation of the urine.

Needless to say, all measures and precautions conducive to asepsis must be observed. Not only must the catheters, endoscopes, etc., be clean and free from organisms, but the urethra itself must be cleaned as far as possible of its pathologic discharges and infecting organisms before

the introduction of the examining instruments; this by irrigations with non-irritating antiseptic solutions.

Sterilization of Catheters and Sounds.—This is a subject to which much attention has been devoted of late years, and repeated experimentation has done much to solve the questions at issue in a definite and tangible manner.

Metal and soft-rubber catheters are relatively easy of sterilization, and by the means most convenient and available; that is, by thorough cleaning with soap and water and subsequent boiling for from three to five minutes.

While the older makes of silk-web catheters (elastic) were not capable of being boiled, because of the non-resisting quality of the outer coating, this does not obtain with the better ones of modern make (more especially the French), which can be repeatedly boiled without injury. For the inferior grade, other means of sterilization must be resorted to, such as prolonged saturation with formalin vapor, following their cleansing with soap and water. Several forms of retainers, to be used in connection with formalin tablets, are on the market. In order to insure sterilization by this method, the catheters must be kept in contact with the vapor for at least twenty-four hours. It must be remembered, however, that formalin vapor is very irritating to all mucous membranes; also, that it is very tenacious to catheters; so that its use in this way must be followed by prolonged rinsing of the catheters in sterile water before introducing them.

Filiform and whalebone bougies may be boiled without injury if the boiling is not continued too long.

The **lubrication** of urethral instruments is a matter of some moment, but it does not always receive the attention it deserves. Oily and greasy substances have no appropriate place in this category. Vaselin is an abomination from every point of view. It rapidly injures soft-rubber or flexible catheters; it does not remain sterile or conduce to sterility in the urethra. By its non-miscibility with water it defeats cocainization of any membranes over which it has been smeared. It is not easily removed from instruments and renders their cleansing difficult. Small pieces of vaselin have dropped off of sounds or catheters into bladders and have acted as nuclei for the formation of concretions.

The best form of lubricant at the present time is that made with gum tragacanth as a base. Such preparations are sold either in wide-mouthed bottles or in flexible tubes. They are unirritating, are aseptic and moderately antiseptic, and are excellent as a lubricant. Casper[20] gives the following excellent formula:

Hydrargyri oxidulati	9.246	(gr. iiiss)
Glycerini	20.00	(f℥ vss)
Tragacanth	3.00	(gr. xlvj)
Aquæ destillati	100.00	(f℥ iij)

In applying the lubricant to urethral instruments it is not necessary to cover them further than the tip and its immediate proximity; but

it is highly desirable to lubricate the meatus and the glans around it, in order to get the best effect.

Introduction of Sounds and Catheters.—For the introduction of soft-rubber or flexible catheters no special anatomic knowledge is necessary. With good preliminary lubrication, the only requirement is to keep the penis well extended while feeding the catheter into the urethra, in order to avoid any transverse folds of mucous membrane that relaxation would make more prominent. When the catheter reaches the bladder, that fact is announced by the issuance of urine from its outer end; or, if the bladder be empty, a drop or a bubble appearing will have the same value.

For the passage of a metal sound, it must be remembered that the urethra has a fixed and a flexible part; that the fixed part is curved, the concavity directed upward. While this curve of the fixed portion is straightened out by the shaft of the metal sound *after the latter has entered* the bladder, and the straightening is then not an uncomfortable condition, it is a further fact that the straightening of this curved part is not so comfortably done if accomplished *during the transit of the instrument*, as, for instance, would necessarily be the case in passing a straight metal sound. That is why it is more agreeable for the male patient to take a curved than a straight sound, although it is possible to introduce the latter, and some operators, indeed, use them regularly.

Passing the Sound; Catheterization.—Probably more praise, on the one hand, and more condemnation, on the other, are connected with this maneuver than with any other in this branch of surgery. Patients appreciate the gentle, dexterous, and painless introduction of a sound, and esteem it more highly, often, than they do much more elaborate manipulations or operative work. It is well, therefore, to cultivate the habit of delicate urethral manipulation as one of the most valuable possessions of the successful surgeon.

Preliminary to the passage of a sound or catheter, both patient and instrument are prepared in order to render the maneuver as easy and comfortable as possible. The patient is directed to lie on his back, the whole body relaxed and at ease. A constrained position will add much to the discomfort and difficulty experienced. The sound is sterilized, warmed, its beak is lubricated, and an additional amount of lubricant is smeared over the meatus and adjacent part of the glans. If the operator holds the sound in his right hand, he stands on the left side of the patient. The left hand supports the penis, retracts the foreskin, and opens the meatus. The sound is held lightly in the *fingers* of the right hand (in the position shown in Fig. 142), its shaft horizontal to and in the line of the fold of the left groin. The first step consists in drawing the penis up over the beak of the sound with the left hand, while the right hand sweeps the shaft or handle across the abdomen to the median line, still keeping it horizontal to the skin surface (Fig. 143). By this time the beak has reached the penoscrotal junction and is entering the fixed part of the urethra. Then, and then only, is it proper to *begin to elevate the shaft*. In elevating the shaft the beak is made to describe the

arc of a circle, whose concavity is directed toward the pubes; it thus follows the curve of the fixed part of the urethra. During the same step the handle and shaft are following a circle in the opposite direction, and the whole instrument is progressing toward the bladder. As there is a

FIG. 142.—SOUNDING OF THE URETHRA (Hyde and Montgomery).

natural widening or bagging of the floor of the bulbous urethra immediately in front of the triangular ligament, the sound often hangs against the lower segment of this ligament. This is prevented by pressing the left hand against the perineum and gently *lifting* the beak over this possible

FIG. 143.—SOUNDING OF THE URETHRA (Hyde and Montgomery).

stumbling-block, the scrotum and testes, meanwhile, resting in the palm of the same hand (Fig. 144). This introduces the beak into the membranous urethra.

The last stage of the passage of the sound is the depression of the

handle between the thighs as its inner end mounts the upward inclination of the prostatic urethra and enters the bladder (Fig. 145).

Having entered the bladder, the sound may be turned on its own axis, the beak sweeping about within the cavity of the viscus. This is satis-

FIG. 144.—SOUNDING OF THE URETHRA (Hyde and Montgomery).

factory evidence of the entrance of the instrument into the bladder. If it cannot be done, it means that the beak is still within the fixed part of the urethra.

In cases of prostatic hypertrophy or pathologic narrowing at the

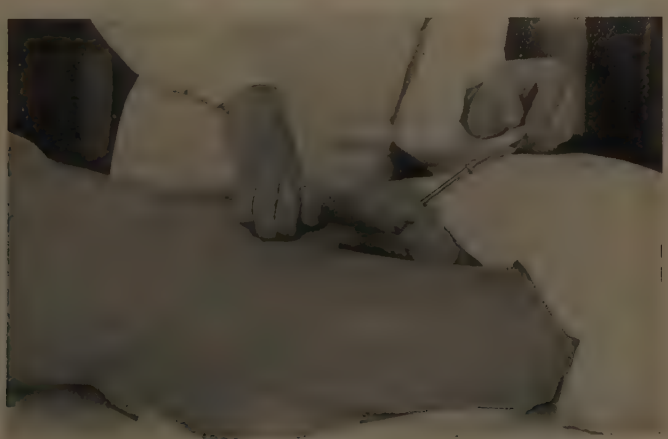


FIG. 145.—SOUNDING OF THE URETHRA (Hyde and Montgomery).

vesical neck it is often necessary to assist the beak in surmounting a slight obstruction that comes from the posterior margin of the vesical outlet by a maneuver similar to that previously executed for lifting it over the triangular ligament; viz., sharply elevating the beak by pressure

through the perineum, or even by means of a finger in the rectum. Under such circumstances it will be felt to override a slight obstruction and to slip into the bladder.

The *withdrawal* of the sound is simply the reverse of the steps taken in introducing it. The handle is brought up from its position between the thighs, is circled toward the patient's head, and then depressed to a level with the abdominal surface; which is accompanied by an outward and upward sweep of the beak in escaping from the curved, fixed portion. After it reaches the pendulous part the sound may be lifted out of the remainder of the urethra.

FIG. 146. — POSNER'S STONE-SEARCHER WITH AURAL TUBE.

Bulb-sounds, commonly used for exploring for stricture, should not be made to pass into or through the compressor urethræ muscle. The muscle is likely to grasp them and hold them so tightly as to occasion injury to that part of the urethra. Steel sounds smaller than No. 18 French should not be used except by the most experienced and adept, as they are liable to puncture the urethral wall and establish a false passage, adding a serious complication to what may be already a difficult situation. Flexible (silk-web) bougies or catheters do not involve this danger, and may be used to the smallest size. Filiform bougies require especial manipulations that are described in the section on Urethral Stricture, p. 539.

DIAGNOSIS OF VESICAL AFFECTIONS.

For the diagnosis of vesical conditions and the differentiation of the urines coming from the two kidneys special instruments and methods are made use of, chief among which are: The stone searcher, the segregator, and the cystoscope, used with and without catheterization of the ureters.

The stone-searcher (Fig. 146) is an instrument that is valuable, but is far from being infallible. When it is introduced into the bladder and obtains the click that is both felt and heard by the operator, its evidence of the presence of stone is conclusive. But its negative evidence is not nearly so valuable; that is, if no click or grating feeling is obtained, that does not by any means prove the absence of stone. Many instances are on record in which the searcher has failed to reveal stone that existed in the bladder, even as multiple calculi and of considerable size.[43, 63]

A calculus may be encysted in a sacculation of the bladder wall, or may be located deeply in the *bas fond* with a prostatic outgrowth overhanging in such a manner that the beak of the searcher cannot be

brought into contact with it, as is well shown in Fig. 147. It is *only by contact* that the searcher obtains its positive evidence. Not so with the cystoscope; this latter may indicate the presence of stone either by touch or by vision, near or at a distance, and its negative evidence is as valuable as the positive. A bladder whose entire cavity has undergone inspection through a good cystoscope without disclosing a stone can be declared free from such a body.

Method of Using the Stone-searcher.—This instrument is furnished with an especially short beak, for the purpose of allowing it to move and turn easily within the bladder. After fulfilling the requirements of asepsis and antisepsis, by irrigation of bladder and urethra, and applying sufficient local anesthesia (after the method described on page 286), from six to ten ounces of tepid fluid are introduced into the bladder and allowed to remain. The searcher is next inserted and is afforded the best opportunity for reaching all parts of the organ by syste-

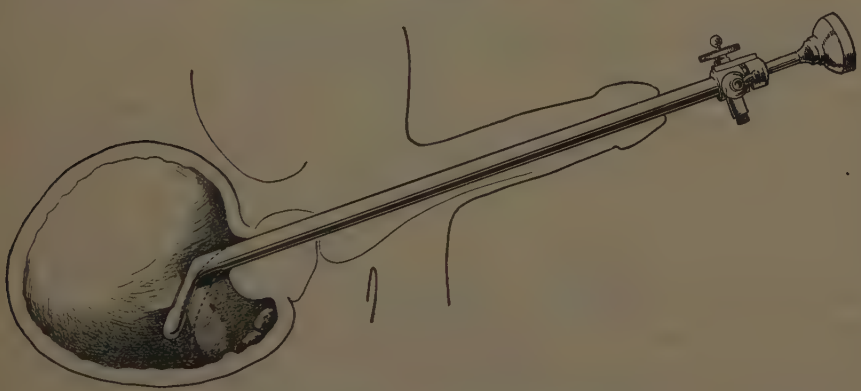


FIG. 147.—ENLARGED PROSTATE RENDERING STONES INACCESSIBLE TO SOUND, BUT EVIDENT TO RETROSPECTIVE UNIVERSAL CYSTOSCOPE.

matic exploration. In every case in which a stone is suspected, but fails of detection with the searcher, resort should be had to the cystoscope in order to determine the matter.

Urine Differentiation.—Following the efforts of the profession the world over to devise a form of cystoscope that would render catheterization of the ureter an easy, or at least a generally successful, measure and bring it within the ability of a large portion of the profession, there were presented, in the decade previous to 1900, by Brenner, Nitze, Casper, and Albarran, cystoscopes that permitted catheterization by experts in a considerable proportion of the cases in which it was essayed (50 or 60 per cent.). This, however, was unsatisfactory; it left failure stamped on too great a proportion of cases in which it was extremely desirable that the urines of the two kidneys be obtained separately. About 1900 a new era was entered upon in this field of work: urine segregators were successively introduced by Harris, Downes, Luys, and Cathelin; and the invention by Koch of the low-tension electric lamp (first applied in the Valentine endo-

scope) led to a revolution in cystoscopes that has rendered them enormously more practical and useful to the profession, simplifying cystoscopy and generalizing catheterization to a like degree.

The use of segregators, because of their apparent simplicity and ease of application, rapidly acquired a considerable vogue with the profession, who were able to apply them, in a way, at least, when they were not able to catheterize ureters. But since 1905 there has been a marked reaction from this position; and even the gentlemen whose ingenuity developed the segregators have shown a tendency to abandon them in favor of the more reliable method of catheterization.

Experience has shown that the usefulness of segregators is restricted to those cases in which catheterization cannot be applied, for one reason or another; and even then their findings cannot be given absolute credence. Illustrative of this unreliability, may be mentioned the instance in which Kuemmel[56] used segregation on a woman on whom nephrectomy had

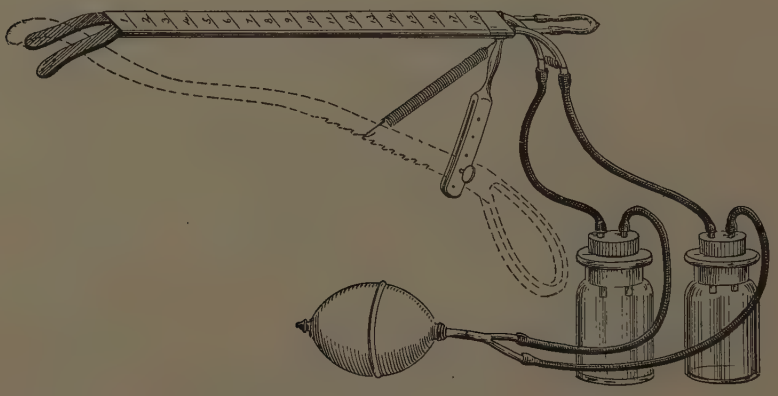


FIG. 148.—HARRIS'S INSTRUMENT FITTED FOR USE.

previously been done on the right side, and yet in the test the only urine that was obtained came from the *right* side. If one should obtain tuberculous urine with the segregator from one side, he would then be unable to say, without further research, whether it had come from—(*a*) the bladder; (*b*) the ureter; or (*c*) the pelvis or kidney of that side. Asymmetry in the location of ureteral orifices in the bladder is so frequent as to preclude reliability of results from segregation.

Segregators and Their Application.—The segregator of Harris (Fig. 148) was the first in the field, that of Downes coming next and being of somewhat simpler construction. For drainage of the urine from the bladder the latter depends on siphonage only, omitting the suction apparatus of Harris; aside from which the instruments do not differ materially. The tubes through which the urine drainage is effected are bound together for the most of their length, but are free at each extremity. They are capable of being rotated on their axis, which permits their being brought together as one catheter, for introduction into the bladder, and then sepa-

rated, giving space for the erection of the water-shed between them, leaving a receptacle on each side from which to drain the individual urines.

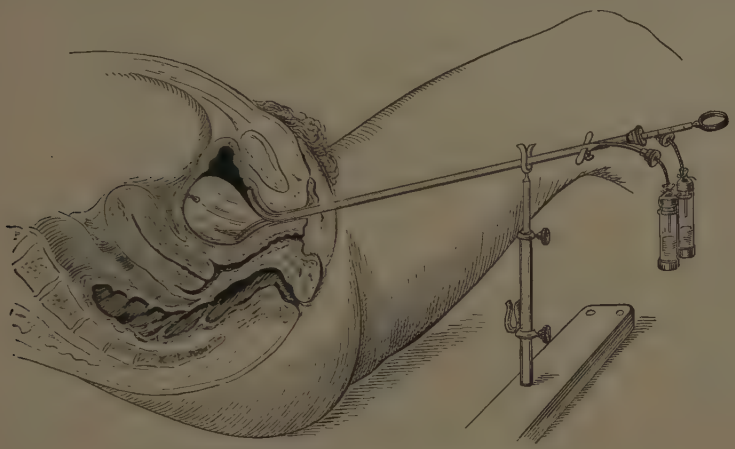


FIG. 149.—CATHELIN'S URINARY SEGREGATOR (Hirst).

In carrying out the procedure two conditions must be avoided, else the object is defeated: the bladder must be kept at rest, free from con-

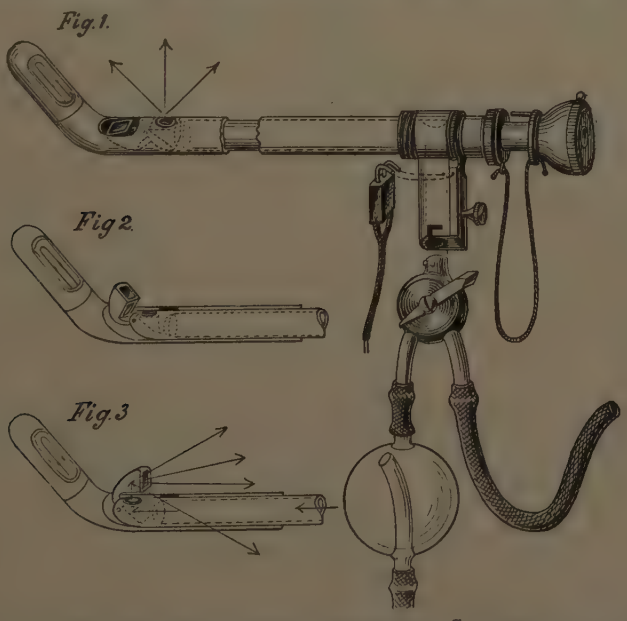


FIG. 150.—SCHLAGINTWEIT'S RETROGRADE CYSTOSCOPE.
Fig. 1, lens within the shaft, giving right-angle view. Fig. 2, lens emerging, giving partial retrospective view. Fig. 3, full retrospective view.

tractions or spasms; and artificial hemorrhage must be avoided. As the segregator must remain within the bladder during the time that urine

drainage is being effected, some form of anesthesia is required. That described on page 286 will usually be found sufficient.

After irrigating the whole urethra and bladder, two ounces of adrenalin solution, 1: 5000, are placed in the bladder for a few minutes. With the patient on his back and relaxed, the double tube is introduced, separated, and rotated, as previously mentioned; to it is attached the fulcrum support, which is subsequently joined to the rectal lever that is now inserted. With the latter adjusted in such a way as to secure considerable elevation of the posterior wall of the bladder between the inner ends of the catheters, its purpose is accomplished. A final washing of the bladder precedes the attachment of small rubber tubes to the outer ends of the catheters, leading into the respective urine bottles. The apparatus is left thus for thirty minutes, in order to obtain the required amount of urine for investigation.

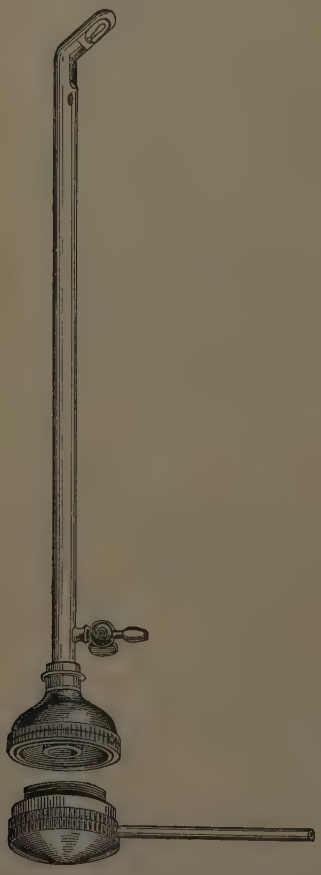


FIG. 151.—NITZE'S IRRIGATION CYSTOSCOPE, FOR EXAMINATION ONLY.

The Cathelin segregator utilizes a movable, elastic diaphragm to make a vertical division of the bladder into two cavities. This diaphragm, in order to be efficient, must be close fitting in its contact with the bladder wall; any break in such contact would defeat segregation. It is readily seen, then, that such an interference is liable to be frequently met with, whether from irregularities in the bladder wall itself, from prostatic outgrowths, bladder contractions or peristalsis, or inaccuracy of adjustment of the instrument. Bladders are not inclined to be submissive to abnormal distention, such as this, for thirty minutes at a time. In contrast to this, it may be mentioned that when ureteral drainage is effected through catheterization, the cystoscope is taken out of the bladder immediately after the catheters are inserted, permitting the drainage to go on with nothing but the small catheters retained; and these are seldom, if ever, complained of, even by the most sensitive patient. Some ureter catheters have been retained for days at a time, without injury.

Cystoscopes and Cystoscopy.—Modern cystoscopy had its beginning in the instruments of Max Nitze and Joseph Leiter in 1875–80.[98] While, previous to that period, commendable efforts at inspection of the bladder had been made from time to time, the cystoscopes mentioned were the first to provide for practical accomplishment of that difficult object.

Since then, under the leadership of Nitze, the work has been prosecuted with tireless energy; and although the stamp of the parent stock is still evident, there has been evolution from the cumbersome and complicated instruments of large caliber, hot lamps, and unreliable cooling apparatus,

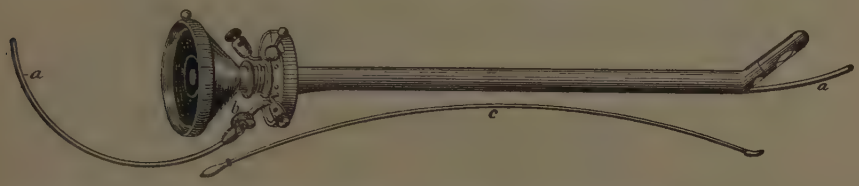


FIG. 152.—BRENNER'S CYSTOSCOPE (SINGLE CATHETERIZING, DIRECT METHOD, LENS AND WATER MEDIUM).
a, *a*, Ureter catheter; *b*, cock; *c*, obturator.

to the light and graceful ones of precision and wide application of the present day; provided with brilliant lamps that do not get hot and means for maintaining a clear field for observation and work.

Modern cystoscopes have certain general features in common, and also points of essential difference. They are intended to fulfil different purposes: some for observation of the bladder merely; others for catheterization of the ureters; and still others for the purpose of operating within the bladder and ureters. Some are used with air as a distending medium, while others are used only with water for that purpose.

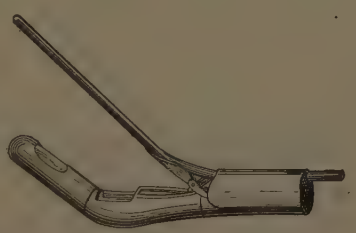


FIG. 153.—ALBARRAN'S LEVER FOR ELEVATING URETER CATHETER.

Of the various cystoscopes on the market at the present time, the most prominent are those made under the names of Nitze,[83] Brenner, Casper,[20] Albarran, Tilden Brown,[13] Bierhoff,[12] and Bransford Lewis.[61, 62, 65, 124, 126, 127, 129] Without going into detailed descriptions of these, their principal features may be mentioned.

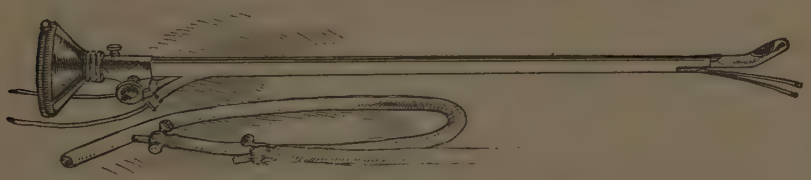


FIG. 154.—BIERHOFF'S CATHETERIZING CYSTOSCOPE.

The several models of Nitze furnish admirable means for observation, for ureteral catheterization, and for operating within the bladder The instruments of Casper, Albarran, Brenner, and Bierhoff (Figs. 152–154) (the latter being purely a modification of Nitze's) aim especially at catheterization, but also afford fairly good views of certain parts of the bladder.

The scope of their field of observation is limited by the fact that they supply views from the concavity of the instrument or the convexity only,

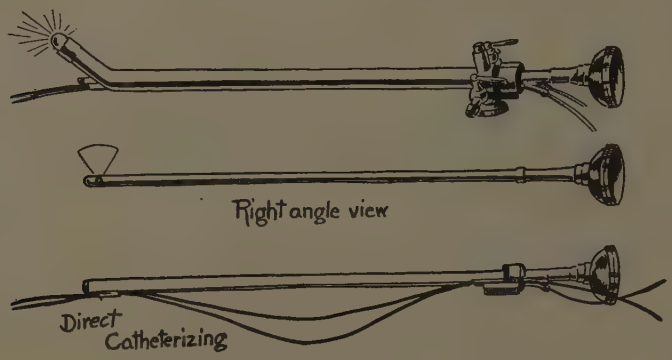


FIG. 155.—TILDEN BROWN'S COMPOSITE CYSTOSCOPE.

but not from both concavity and convexity. The cystoscopes of Tilden Brown (Fig. 155) and my own (the Universal) work on both concavity

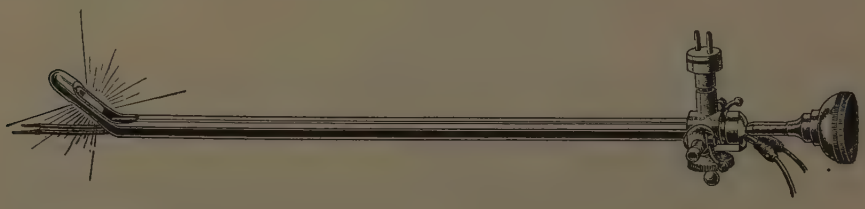


FIG. 156.—THE BRANSFORD LEWIS UNIVERSAL CYSTOSCOPE, DIRECT CATHETERIZING TELESCOPE IN PLACE, ILLUMINATING ABOVE AND BELOW (WATER MEDIUM).

and convexity, the lamps being so arranged in these that they shed light in both directions, and lenses are provided to supply views in both directions.

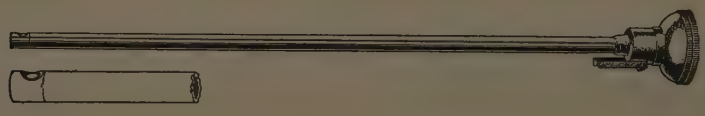


FIG. 157.—RIGHT-ANGLE AND RETROSPECTION TELESCOPE FOR UNIVERSAL CYSTOSCOPE.

Both of these instruments provide for catheterization. The Universal of Lewis fulfils the following specific objects: (1) Direct, forward

FIG. 158.—OBTURATOR FOR UNIVERSAL CYSTOSCOPE.

view; (2) double catheterization by the direct method; (3) right-angle view; (4) retrospective view; (5) double catheterization by the

indirect method; (6) irrigation of the bladder for removal of blood and pus during manipulation, maintaining a clear field, and regulating the quantity of distending fluid (water).

Air cystoscopes are simpler in construction than those mentioned; they are without lenses, afford a very much smaller field of observation, and the chief advantage pertaining to them is that of permitting the operator to work notwithstanding fairly active bleeding into the bladder at the same time. Lens instruments are used with water-distention, a more comfortable and natural medium than air. They afford a much larger field of vision and better views within the bladder; and when provided with means for taking care of hemorrhage, are to be preferred to air instruments.

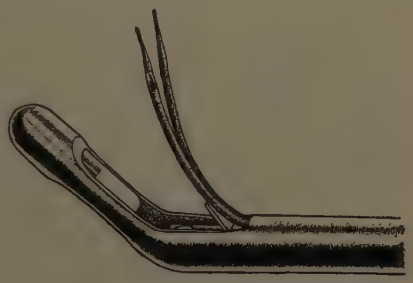


Fig. 159.—Indirect Catheterizing Arrangement, Universal Cystoscope.

Technic of Cystoscopy.—There are certain preliminary requirements common to the use of all cystoscopes. Sufficient deadening of the sensibility of bladder and urethra must be secured in order to effect easy or satisfactory manipulation. As to whether an anesthetic is necessary depends largely on the sensitiveness of these organs. In many, the whole procedure is carried out with a surprising lack of complaint from the patient. In most cases, however, either local or general anesthesia must be provided.

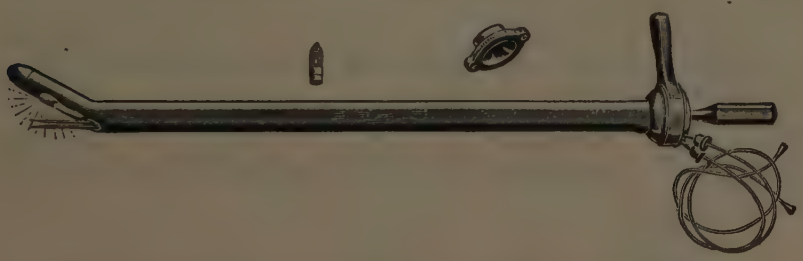


Fig. 160.—Bransford Lewis Double Male Ureter Cystoscope (Air Distention).

The bladder must be well cleansed, freeing it of mucus, pus, or blood that would cloud the distending fluid and obscure the vision. This preliminary washing is done through a soft-rubber catheter, following which the anesthetic is applied and clear fluid is injected and allowed to remain in the bladder, to serve as the distending medium. With the Lewis universal cystoscope, the washing may be done through the sheath of the instrument, which carries a large, full stream back and forth; and no time need be lost in inserting the catheterizing telescope through the sheath after the cleansing is effected.

A sufficient quantity of fluid must be introduced to afford working space for the cystoscope. Less than three ounces in the bladder is impracticable; from five to ten ounces is serviceable; while some very atonic bladders are best examined when containing even more than that. Bladders that are contracted or intolerant of sufficient fluid are rendered more tractable by elevating the pelvis (semi-Trendelenburg posture), which removes the pressure from the neck, the tenderest part.

Anesthesia.—It is only in a few exceptional cases that general anesthesia is required, some form of local anesthesia amply sufficing for the

FIG. 161.—POSITION FOR CYSTOSCOPY AND CATHETERIZATION OF THE URETERS. THE BRANSFORD LEWIS CYSTOSCOPIC TABLE.

remainder, with the exception of the few in which no anesthetic at all is necessary.

The posterior urethra and the vesical neck are the points requiring the anesthetic influence, the anterior urethra and bladder wall in general requiring none at all.

The favored mode of securing this effect has been that of depositing 20 or 30 minims of a 4 per cent. solution of cocain in the posterior urethra, after emptying the bladder of all contents. The solution thus deposited is not inclined to remain in the posterior urethra, but under the influence of the muscular apparatus surrounding the canal passes back into the bladder and soon mixes with the urine as it comes from the ureters. It is thereby diluted, and its effect is transient. While this

method is serviceable to a degree in patients not extremely sensitive, it is not satisfactory where there is a state of inflammation and supersensitiveness; to meet which conditions I some years ago devised and have been using with much satisfaction the urethral tablet depositor[61]

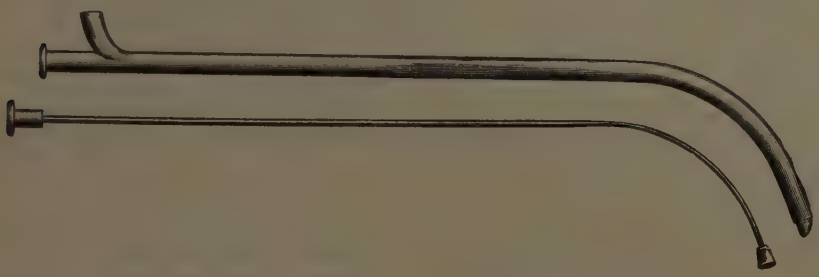


Fig. 162.—The Bransford Lewis Urethral Tablet Depositor.

depicted in Fig. 162. With this instrument tablets of either cocain or alypin or novocain (one-half to one grain each) are deposited well within the posterior urethra, are allowed to rest there for a minute until macerated, and then, by to-and-fro movements of the depositor, are spread over the membrane in that neighborhood. A thick smear and *confined application* of the drug result from this mode of using it, and the effect is much more serviceable and lasting. Since the posterior urethra and bladder possess little absorptive power, there is little likelihood of observing toxic effect from this procedure, even where two or three grains of cocain are used. Alypin and novocain are considerably less toxic than is cocain, and are almost equally as effective.

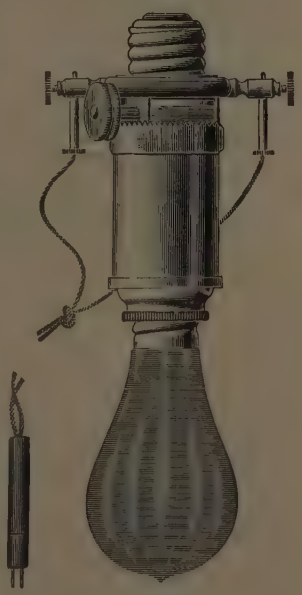


Fig. 163.—"Gem" Current Reducer and Controller.

Loss of sensitiveness of the vesical neck may be tested by further manipulation of the depositor; which, when attained, is followed by filling of the bladder with clear fluid and the introduction of the cystoscope.

The light having previously been tested and adjusted, is now turned on and a preliminary survey of the field is taken. Supposing the cystoscope to be of the Nitze type (the lens on the concavity), the beak is at first pointed toward the front wall of the bladder. As the operator wishes to pursue his investigation he turns the instrument on its axis, bringing into view in succession the lateral wall, one of the ureters, the trigone and bas fond, the other ureter, and then the opposite lateral wall. Only a part of the posterior wall comes into view with this form of instrument; so that, in order to obtain a complete view of the posterior

wall, it is necessary to withdraw this one and introduce one giving a straight or direct view, from the heel (the Brenner type). In working with the Brown or my own universal model, the sheath is not withdrawn, the exchange of views being made by the successive introduction of the telescopes supplying the several views. The sheath also serves as a full-sized catheter, furnishing means for ready change of the fluid or regulation of its quantity, through the cocks at the sides of the sheath. This also permits the displacement, by a forcible stream of water, of flakes and shreds of muco-pus that often float in the fluid and obscure the vision. In one instance observed by myself heavy flakes of muco-pus hung in a veil-like manner from the walls of a cancerous bladder, and would have wholly defeated the investigation had not advantage been taken to wash them out of the way, in the manner mentioned, after which a beautiful view was obtained.

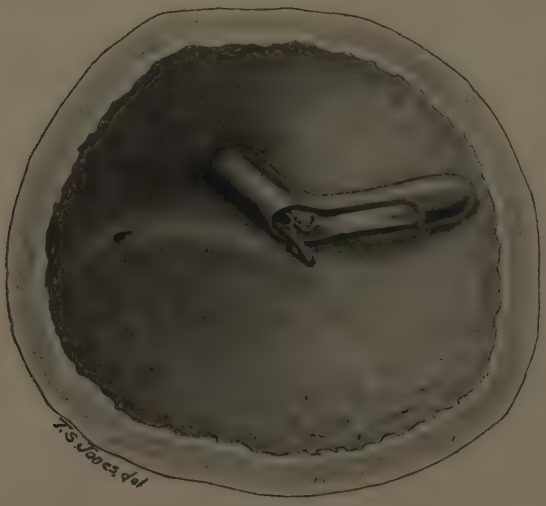


FIG. 164.—SHOWING THE SHORT DISTANCE BRIDGED BY THE CATHETER IN THE DIRECT METHOD, UNIVERSAL CYSTOSCOPE.

Catheterization of the Ureters.—Practically all modern catheterizing cystoscopes provide for double catheterization at the same sitting, either by two catheter-channels, or a single channel with a removable slide (Casper) which permits a second catheter to follow the first after the first is dislodged from the channel. Provision for double synchronous catheterization is absolutely essential.

With the cystoscope in place, the light turned on, and the ureteral catheters lying well within their channel or channels, according to the particular instrument in use, search is made for one of the ureteral openings. They are to be found at the upper angles of the trigone, about three-quarters of an inch from the median line, and about an inch from the inner extremity of the urethra. They are to be recognized as small slits or dimples in the membrane, possibly on the apex of a little papilla; and their recognition is confirmed by observing the issuance from them, at short intervals, of jets of urine that swirl in the surrounding fluid in a characteristic manner. If this urine is tinged with blood or pus, or artificially, by previous hypodermic injection of indigo-carmin solution, it is even more readily recognized. The openings of the ureters are not always placed at the same location, nor are they always symmetrically located; one may be quite near the median line, the other at a considerably greater distance from it. Peristaltic movements either of the blad-

der or of the intestines behind it produce changes in their location and relationship, even in the same individual.

Inflammatory conditions of the bladder-membrane often increase the difficulty of detecting the ureteral openings, by adding to the number of dimples and depressions that resemble the openings, or by sinking the real opening into the edematous membrane in such a way that it is not easily recognized. But experience and practice will remove much of this difficulty.

A ureteral opening having been detected, the cystoscope is brought as near as may be to it, the catheter is aimed at and pushed into it, then gradually threaded up the ureter as far as appears desirable. If it is desired only to draw urine from that kidney, the insertion of the catheter four or five inches will be sufficient; but if it is desired to explore the ureter for stone or stricture, the catheter is passed eight or nine inches after it enters the opening.

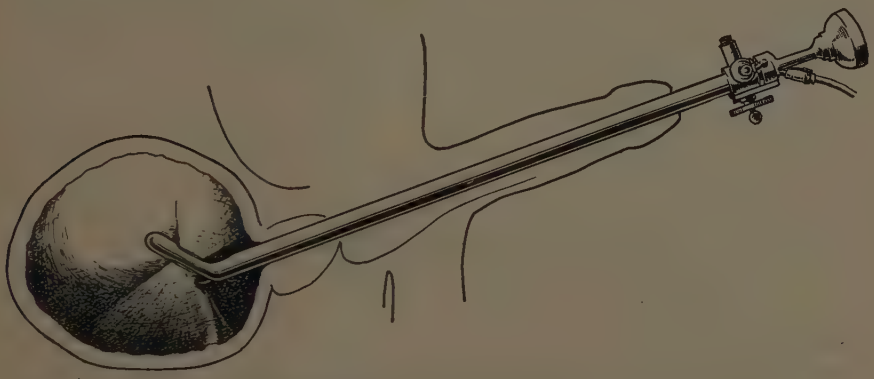


FIG. 165.—URETER CATHETERIZATION BY THE DIRECT METHOD, ORDINARY CONDITIONS; SHORT DISTANCE TO BE BRIDGED.

Having finished with that side, the cystoscope is turned to the other ureter opening and the same procedure is carried out. Before withdrawing the cystoscope it is usually advisable to allow some of the fluid to escape from the bladder, rendering the patient more comfortable while the catheters are draining during the next half-hour or more; this is done by opening the drainage cocks of the cystoscope.

The cystoscope lamp having been extinguished, the instrument is carefully withdrawn from the bladder, the catheters at the same time being fed into the instrument and remaining in their same position within the ureters. Jerky movements of catheters at this point are liable to cause the appearance of blood-cells in the urine subsequently drained through them. If carefully executed, no difficulty should be met with in this procedure.

The outer ends of the catheters are next wiped with moist, aseptic gauze, and after the first few drops of urine are thrown aside one catheter (that from the right ureter) is led into a sterile test-tube or bottle, marked R, while the other drains into a tube marked L. In order to be doubly

sure of preventing confusion of the two sides (a matter that is all-important) it is well to have the catheters of different colors, a light-colored one for the left, and a red or dark-colored one for the right.

Two to four drams of urine thus drained are usually sufficient to make the required examinations, both microscopic and chemical. Gravity beads are used for taking the weight. If there is such an amount of red blood as to dominate the field of a microscope-slide, it may be caused to disappear by adding a few drops of acetic acid, leaving a clear view of pus, epithelia, or casts.

Ureter Catheterization in the Female.—The female bladder usually presents less difficulty with respect to ureter catheterization than the male, because of the shorter length of urethra, and the lessened resistance offered the distending medium, whether air or water. It has been on this account that the Kelly-Pawlik method has attained such popularity for women, while it was inexpedient in men. By supplying sufficient pelvic elevation, in women, either in the dorsal or the knee-breast position, the bladder tends to dilate from atmospheric pressure alone, without the forced distention from air or water within. While this is the case with

FIG. 166.—BRANSFORD LEWIS DOUBLE FEMALE URETER CYSTOSCOPE (AIR DISTENTION).

most women, it is a further fact that in certain ones the Trendelenburg posture does not suffice to secure the dilatation, and forced distention is required—easily furnished in the newer air instruments by means of the rubber bulb apparatus. The author's air cystoscope for women (Figs. 166 and 167) is thus equipped, besides adding the following features to the Kelly model of bladder speculum: A cold electric lamp, placed in the beak, affording ample, steady, and complete illumination of the field of observation and work; two tubes on the lower wall of the cystoscope, for conducting the two ureter catheters and giving easy control over them, and doing away with the necessity of employing metal catheters, which are less safe and less comfortable to the patient. A slightly magnifying window sharpens the image observed and retains the air that is pumped in, in certain cases. With this form of cystoscope it is unnecessary to employ one of such great caliber that preliminary dilatation of the urethra with graduated dilators is required. Caliber 26, French, affords an ample field for catheterization and ordinary purposes of cystoscopy. Local

anesthesia is provided in the same manner as already described, by means of the tablet depositor (page 287).

If a lens cystoscope be used, the technic does not differ essentially from that employed for the male.

Cystoscopy with Air-distention.—As previously remarked, the chief advantage derived from the air-cystoscope is the ability it furnishes to the operator to work in the bladder or ureter notwithstanding quite active bleeding into the bladder. The blood is taken care of by dropping the patient into the extreme Trendelenburg posture, which allows the blood to gravitate to the vault of the bladder, away from the operative field. This work relates to intravesical and intraureteral manipulations, including catheterization.

Through the author's operative cystoscope (Fig. 168), and with the aid of the several appurtenances pertaining thereto, foreign bodies and small calculi may be grasped and removed, applications may be made to the bladder wall with a swab, and galvanocauterization effected. The field of intraureteral work within the sphere of this instrument embraces the dilating or incision of the ureteral orifice, sounding of the ureter for stone, and removal of a stone from the lower end of the ureter.[62]

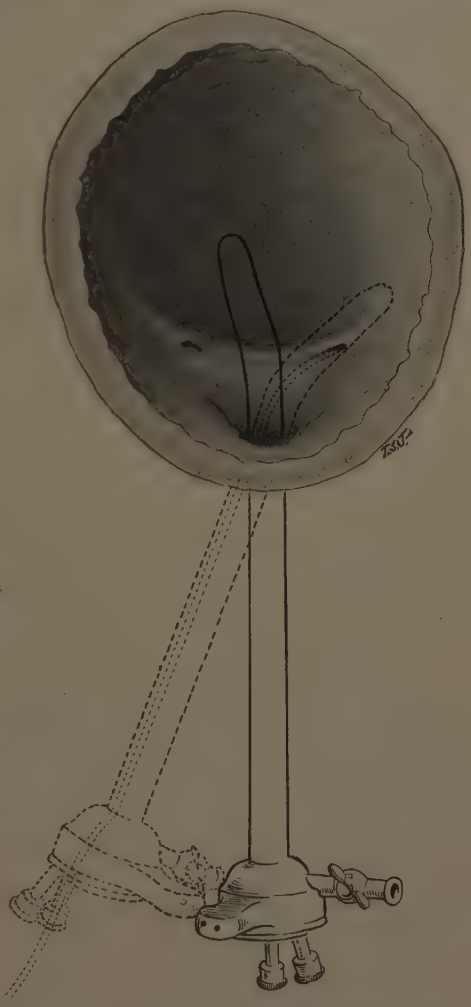


FIG. 167.—FEMALE URETER-CYSTOSCOPE (AIR) AS INTRODUCED AND DEFLECTED FOR CATHETERIZATION OF URETER.

Since air is an unnatural and less comfortable medium for contact with the bladder membrane than water, a more pronounced anesthetic effect is desirable here. It is furnished in the same manner, by means of the tablet depositor. The bladder being emptied of all contents, the cystoscope introduced, the obturator withdrawn, the patient is lowered into the Trendelenburg posture. The bulb-aspirator is used to pump out the little urine that may

have collected in the mean time. The light is turned on and the ocular window placed in its position. An assistant keeps up moderate, gentle inflation of the bladder through the double-bulb air-pump, using warmed, sterile air for the purpose. When it is desired to make use of any of the

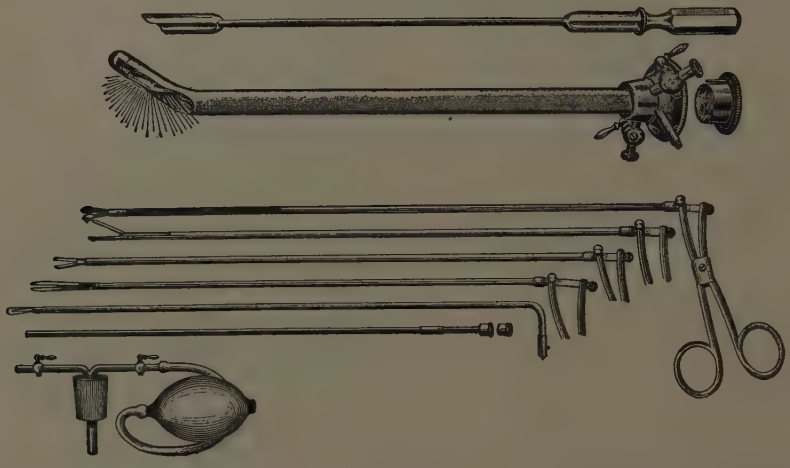


FIG. 168.—THE BRANSFORD LEWIS OPERATIVE CYSTOSCOPE AND APPURTENANCES PERTAINING THERETO.

dilators, forceps, etc., a perforated window is used instead of the plain one, which permits the operator to manipulate while within the direct field of his vision, and also to maintain sufficient air in the bladder for distention (this with continued attention from the assistant). Catheterization and sounding are effected through the conducting tube that passes through the perforated window, in this instrument.

FIG. 169.—BLADDER PHANTOM.

Difficulties and impediments to cystoscopy and catheterization of the ureters are many and are sometimes discouraging. The procedures are of a delicate nature, requiring much practice and adaptibility to that kind of work. Considerable assistance may be derived from practice with a phantom or imitation bladder (Fig. 169).

Of the difficulties met with, those coming from insufficient anesthesia are probably the most frequent, consisting of bladder contractions and resistance, and manifestations of pain on the part of the patient. Insufficient working-space, from lack of bladder capacity or too little fluid intro-

duced; free bleeding from the posterior urethra, bladder, or ureters; displaced or obscured ureteral openings; vesical tumors, or intravesical prostatic lobes; strictured urethra, strictured ureters or those obstructed by calculi; "precipitate" bladder or deep bas fond, as indicated in Fig. 170, are some of the causes of difficulty in connection with cystoscopy or catheterization. If it is found that sufficient local anesthesia is not attainable by the method already advised, general anesthesia may be employed or spinal anesthesia may be substituted, three-fourths to one-half grain of alypin being injected into the subarachnoid space for that purpose. All difficulties must be met with intelligent appreciation and appropriate action as they are encountered.

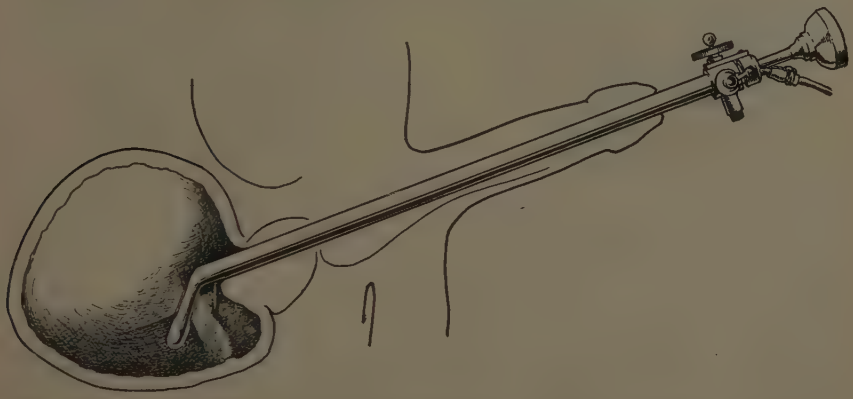


FIG. 170.—PRECIPITATE BLADDER; URETERS INACCESSIBLE TO DIRECT METHOD OF CATHETERIZATION; INDIRECT METHOD IN USE.

MALFORMATIONS OF THE BLADDER.

Absence of the Bladder.—In certain individuals the bladder is congenitally absent, the ureters then opening into the urethra, the vagina, or the rectum. This condition is rare. Its indications for correction are largely met by the wearing of a rubber urinal; but there is little prospect of reclamation to the normal by operative measures, as in such instances the accompanying malformations are so great as to dwarf the urgency of relief from this condition.

Supernumerary or multiple bladder is another rare congenital anomaly. It is sometimes confused with congenital diverticula of the organ. Supernumerary bladder occurs in connection with reduplication of other pelvic organs, such as double penis, vagina, etc., and is but a phase of general congenital anomaly. It requires no especial operative attention.

Diverticula or sacculations of the bladder are both congenital and acquired. The former are incidental to congenital lapses, such as patent urachus, while acquired diverticula are almost invariably associated with and secondary to some obstructive condition that interferes with the outflow of urine from the bladder.

The congenital variety are usually not troublesome on their own account, and unless observed in the course of a cystoscopic examination

for some other condition, may go undiscovered until disclosed by post-mortem examination. The acquired variety, however, are not prone to lead such an innocuous existence. Both through associated conditions, to which they are due, and because of their own possibilities for evil, the individual in whom they occur may be subject to inveterate suffering.

The typical diverticulum of this kind (acquired) begins as a small

FIG. 171.—PHOTOGRAPHIC CYSTOSCOPIC VIEW OF THE URETER RIDGE AND PAPILLA, WITH THE URETER OPENING SITUATED ON THE APEX OF THE PAPILLA (Nitze).

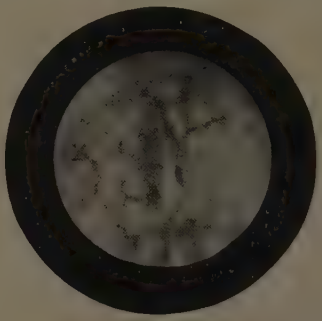
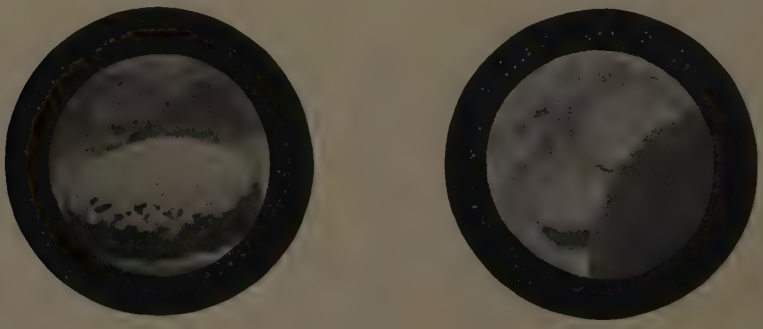


FIG. 172.—SHOWING THE URETER OPENING WITHOUT RIDGE OR PAPILLA; MARKED VASCULARITY (BOTH ARTERIAL AND VENOUS) OF THE ADJACENT MEMBRANE (Nitze).

herniated protrusion of vesical mucous membrane between the meshes of muscular fibers of the bladder wall. The detrusive pressure of the obstructed, forcibly contracting bladder meets with the counterpressure of the contained urine, starting the hernia of mucous membrane. Repetitions of this effect eventuate in a sacculation of membrane, small at its neck, but possibly as large as a walnut or larger, as it protrudes from the



A B

FIG. 173.—URIC STONES IN THE BLADDER (Nitze).
A, Large, oval uric stone in the bladder; B, showing posterior middle lobe of prostate and two uric stones lying in the bas fond.

bladder wall. It may or may not be covered by peritoneum, according to the location where it is attached.

With the urine clear and sterile, in such a case, there may be no local or systemic reaction, but once infection has entered, conditions are materially changed. The sacculus, having no power to drain or empty itself, retains decomposed urine indefinitely, undergoes chronic infective inflammation, and perpetuates the cystitis that ensues. Conditions thus

established are favorable for the development of calculus within the diverticulum; and at the same time its inclosure within such a cavity makes it especially difficult of detection by means of the instrument usually employed for determining the presence of calculus, the stone-searcher. The

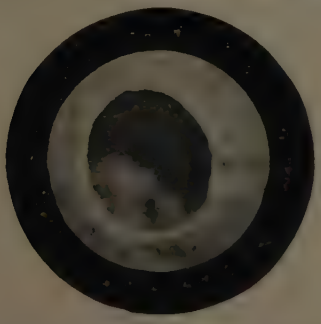


FIG. 174.—CONGENITAL DIVERTICULUM IN THE BLADDER WALL (Nitze).

The smooth round edges, as well as the bottom of the cavity, are plainly evident, as distinguished from the acquired form of diverticula; no other sacculations appear in the wall of the bladder.

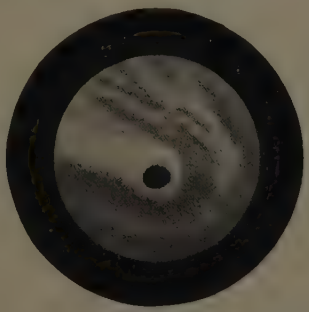


FIG. 175.—DILATED URETER AND URETERAL OPENING (Fenwick).

cystoscope is the means, *par excellence*, for disclosing both sacculation and stone (Figs. 173, 175).

It is common to observe sacculations of variable number and size in making cystoscopic investigation of prostatic cases.

Although there is little contractility in the walls of diverticula, which practically consist of nothing but overstretched mucous membrane, still, when the obstructive condition that has caused it is removed, gradual shrinking or even disappearance of the sacculation often ensues. A very large diverticulum that had probably existed for a number of years, in a case under my own observation, was seen to follow this course after the removal of neurotic obstruction at the vesical neck.

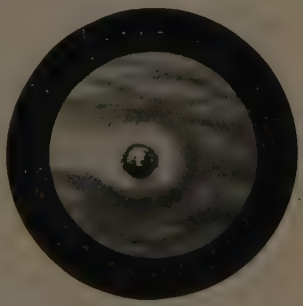


FIG. 176.—LIME OXALATE STONE PROJECTING FROM URETERAL OPENING (Fenwick).

NOTE.—This would be favorable for removal through the operative cystoscope by means of the forceps, possibly with preliminary incision or dilatation of the orifice with the appropriate ureter instruments.

Treatment of sacculated bladder may relate to either palliative or radical measures. The palliative consist in regular, periodic catheterization, or even the retained catheter, for the purpose of preventing any accumulation of urine that might contribute to further stretching of the bladder walls; gentle irrigation of the organ with antiseptic and tonic fluids; the use of vibratory and other abdominal massage; Faradic electricity; strychnin internally; reconstruction of the general health.

The more radical measures relate, first, to the removal of any possible obstruction to the escape of urine from the bladder or urethra; and, second, the obliteration or removal of the diverticulum itself in case that becomes necessary.

While it is possible, in a few cases of sacculation, to incise the orifice and release pent-up fluid or a stone contained therein, at the same time establishing free communication between the cavity of the bladder and that of the diverticulum, the usefulness of this procedure will doubtless prove limited. Complete excision of the sac, with closure of the resulting aperture through the wall of the bladder, offers the only hope of reclamation in severe cases. This method has been successfully executed in nine instances, so far, with improvement or recovery in all but one of the cases. The operators were: Péan,[89] Czerny,[19] Riedel,[96] Pagenstecher,[86] von Eiselsberg,[112] Young,[123] Wagner.[113]

The cases embraced both the acquired and congenital forms of diverticula. In brief, the operation consists in gaining access to the diverticulum through a suprapubic incision, from the outside of the bladder and extraperitoneally, if possible, or from the inside of the bladder if necessary. In the former case the sacculation is definitely outlined, is excised by a circular incision passing through all coats of the organ, and the resulting opening is closed by purse-string or interrupted chromicized catgut sutures, the edges of the mucous membrane being turned in to contribute to security of closure. If it be found necessary to work from within the bladder, as may happen when the sacculation is attached to the posterior wall, access is obtained by first opening through the anterior wall, after which the mucous membrane is severed at the margin of the saccular orifice and dissected from the underlying tissues; this paves the way to closure of the resulting opening in the vesical wall in the manner before mentioned, and also to the filling by granulation of the space behind the bladder, previously occupied by the tumor. Outside drainage of this cavity may or may not be required. Drainage of the bladder is effected either by catheter retained in the urethra or through the suprapubic wound, or both.

Hypertrophy of the bladder is a condition secondary to some other lesion, either obstructive or irritative. The obstructive lesion calls for gradually increasing expulsive efforts on the part of the detrusor muscles to evacuate the organ, and thereby excites increased growth and strength of the muscular structure of the bladder. The irritative lesion (stone, tumor, or infection) excites the organ not so much to exaggerated effort as it does to frequent repetition of the effort, muscular overgrowth being the result. This form is often accompanied by shrinkage in the general size of the bladder and decrease in its capacity, and is termed *concentric hypertrophy;* while the obstructive form as often results in wide dilatation of the organ, notwithstanding the increase of muscular tissue supplied, to which condition the term *eccentric hypertrophy* is given. With the gradual development and increase of the obstructive effect and overpowering of the muscular tone of the bladder, eccentric hypertrophy gradually merges into an atonic condition that renders it incapable of exerting sufficient expulsive force to empty the bladder; a certain amount of "residual urine," as it is termed, is then left in the bladder after each urination. This varies in amount from a few ounces to one or two pints or more (see Retention of Urine, p. 299). With concentric hypertrophy there is usually no residual urine, save in the instances in which the irritative factor becomes obstructive also.

The overgrowth of muscular structure shows itself not only in thickening of the wall of the bladder as a whole, but also in the numerous bands of muscular fibers that criss-cross the inner walls in every direction; that might aptly be called columnæ vesicæ, in imitation of the term applied to the interior of the hypertrophied heart.

In the interspaces between such bands of muscles unresisting spaces are left that receive the counterpressure of the urine at each expulsive effort; gradually these dilate and form pockets, small for a time, but finally growing into sacculi or diverticula, with the continuation of the obstruction and backward pressure.

The two forms of hypertrophy described above usually require different measures for their relief: removal of the obstruction, for the eccentric form, and removal of the source of irritation, for the concentric.

Urethral stricture and prostatic hypertrophy are the most frequent

FIG. 177.—MAN AND WIFE, SUBJECTS OF EXSTROPHY OF THE BLADDER.

causes for the first-mentioned, while calculus is the most frequent cause for the latter.

Both conditions may or may not be amenable to restoration on the adoption of the required measures. A "dilated" bladder may contract to a surprising degree after prostatectomy, even though it appeared to be hopelessly atonic; while a "contracted" bladder may need not only the dissipation of a chronic infection, but may have to be brought up to its former capacity and tolerance of fluid by repeated stretching and irrigation.

Atrophy of the bladder is observed when the reservoir function of the organ is done away with by continuous abnormal escape of the urine as fast as it enters; as, for instance, in the presence of vesical fistula that keeps the bladder constantly drained and unable to fulfil the office for which it was created. Its elasticity, dilatability, and contractility are all disposed of under such circumstances, leaving it an inert sac with thinned walls and but little muscular structure.

Exstrophy of the Bladder.—A congenital deformity of comparative frequency is that of exstrophy of the bladder, in which, in the course of fetal development, there is failure of union anteriorly between the two lateral halves of the bladder and of all in front of it, including the abdominal wall, the pubic symphysis, and the roof of the urethra; the resulting space is filled in by the posterior wall of the bladder and the floor of the urethra. This part of the genito-urinary tract, in other words, lacks the "roof" that would naturally have been formed by the union of their lateral halves anteriorly. It is a condition of extreme epispadias.

The condition that results is deplorable (Fig. 177). The reddened and irritated mucous membrane of the bladder, instead of receiving the support and protection naturally given it, protrudes awkwardly, in a location in which it is constantly exposed to contact with clothing; the neighboring parts are unceasingly bathed in scalding urine that issues from the exposed mouths of the ureters; and the urinous odor that envelops the patient is hardly less disagreeable to him than to those who must associate with him.

The penis is rudimentary and undeveloped, and the largest service to be expected of it is that of acting as a gutter for guiding the urine into a rubber urinal strapped to the thigh of the patient. Anomalies of the testes often coexist.

In women the exstrophic condition is similar, there being no covering for the bladder or the urethra, and a wide space intervenes between the ends of the pubic bones where the symphysis should be (Fig. 177).

Naturally, inexhaustible efforts have been expended in the laudable endeavor to correct such wretchedness and reclaim such sufferers to comfortable existence; but only partial success has crowned the endeavor.

Plastic methods of operation have, in many instances, attained the immediate purpose for which they were designed. By newly formed flaps, artfully obtained from adjacent structures, they have secured covering for the protruding bladder; they have succeeded in forming a receptacle, instead of the bulging tumor; but, one and all, they have *failed to establish a sphincter* to fulfil the retentive function that is requisite to answer the needs of a urinary reservoir. All such autoplastic methods are doomed to defeat at the outset. Even those that go farthest toward making a closed cavity are still farthest from securing relief to the patient, as it has been found that in just such instances decomposition of urine, deposition of phosphatic material and irritating substances on the inner surfaces of such receptacles have been the greatest. Under such circumstances it has been found almost invariably necessary to reopen the cavity, for better drainage and freer access to cleansing measures.

Simon,[104] Czerny,[18] Pozzi,[94] Maydl,[75] Sonnenburg,[103] Segond,[102] Murray,[80] Harrison,[44] Rutkowski,[99] Trendelenburg,[109] Pancoast,[87] Wood,[120] Heydenreich, Thiersch,[108] Mundel, Fowler,[29] LeFort,[60] Rydygier,[100]—all have had a hand in the reconstructive work for exstrophics. Practically all such work has been divisible into two groups: Those having for their object the construction of a urinary reservoir with the bladder as a basis (autoplasty); and those that purpose the diversion of the urinary channel either externally, in a more suitable or convenient direction, or into the lower bowel or vagina, with the intention of converting these organs into

receptacles for the temporary retention of the urine. The latter plan has been attended with far greater success than the former. Maydl, for instance, who formerly practised an autoplastic method of his own, has definitely abandoned it for one of the other kind, in which (for description, see "Wiener medicinische Wochenschrift," 1896, xlvii) he excises from the bladder wall its trigone, including both ureters and their openings, and implants the whole into the wall of the colon (sigmoid flexure); then, dissecting out and removing from the body the remainder of the bladder, he closes the resulting abdominal aperture. The urine thereafter drains into the rectum through ureters that still retain their natural outlets, and no exposed tissue remains in the pubic area. The rectum acquires tolerance of the presence of the urine, as well as ability to hold it for several hours at a time.

The chief danger in this and other similar methods of operating arises from the liability of infection extending from the bowel into the ureters and renal pelves, producing pyelonephritis. Nevertheless, extended experience with the method and reports of individual cases have shown that it has given very much more favorable results than any other hitherto devised. Hartley[45] has collected the results of forty-six cases operated upon by this method, with an ultimate mortality of seven cases, or 15 per cent.; of which 6.5 per cent. represents the effects of infection of the ureters and kidneys, and 8.5 per cent. represents shock and surgical conditions avoidable by improved technic and better selection of cases.

In concession to the sentiment that opposes the sacrifice of any organ of the body that can be saved, Frank[30] suggested artificial vesicorectal fistula as a safer and better mode of effecting anastomosis between the bladder and the bowel. But while plausible in theory, its high mortality as applied experimentally to dogs, and the little experience with it so far noted in the human being, makes one reserve judgment on its merits.

Moynihan, in a well-illustrated contribution,[78] reports having transplanted not only the trigone but the whole wall of the bladder, together with the ureters, in a male exstrophic, with complete success, the patient having been able to hold urine in the rectum for from three to five hours.

DISTURBANCES OF URINATION.

Under this heading may be described vesical retention and enuresis, opposing conditions.

Retention and atony are so intimately related that they may well be described together. Prolonged or repeated retention, with overstretching of the organ, from any cause whatever, results in weakening of the detrusor muscles, reducing their contractility and producing the condition called atony; while, on the other hand, atony itself contributes to further retention by reason of the inability of the weakened muscles to expel the urine. Thus is established a vicious circle that forms the intimate relation between the two conditions.

Normal urination is accomplished through the combined effort of nervous impulse and muscular action. The bladder fills with urine, and by sensory connecting nerves notifies both brain and vesicospinal center of that fact; the brain arranges for appropriate conditions, as to time

and place for urination, whereupon the spinal center transmits the motor messages that both inhibit the usual contraction of the sphincters, causing them to relax, and at the same time excite the detrusors of the vesical wall to activity, causing them to contract; the harmonious action of the two systems of muscles effects the normal expulsion of the contents of the bladder.

If there is incoördination or loss of balance between these two systems, detrusive and sphincteric, there is derangement of the function of urination. If the sphincteric function be weakened or abolished, there is leakage or incontinence; if the sphincteric energy be excessive, as compared with detrusive power, there is retention. Sphincteric energy is *relatively* stronger when the detrusors are weakened from any cause. In atony, for instance, while the sphincters may not actually have gained any strength through the establishment of that condition, they offer sufficient resistance to the now weakened detrusors to interfere with the discharge of their function; a certain amount of urine is left over after each urination. The insertion of a catheter removes the effect of the sphincters, opens the outlet completely, and restores the original balance between the two opposing systems; the detrusors demonstrate their remaining, if weakened, power and readily empty the bladder.

These muscular systems must be well balanced, therefore, to maintain the normal filling and emptying of the bladder.

Impairment of coördination between the two systems results from local or central influences, acute or chronic conditions. Thus, retention may be derived from (1) mechanical obstruction to the outflow of urine; (2) nervous affections; (3) infections; (4) habits or circumstances affecting the individual. Etiology has such an important bearing in furnishing a clear insight into the subject under discussion that it has been deemed desirable to introduce the following schematic classification as to caustion:

CLASSIFICATION OF CAUSES OF RETENTION AND ATONY.

- Retention and Atony
  - (1) Mechanical obstruction
    - Urethra
      - Narrow meatus.
      - Stricture.
      - Imperforate urethra.
      - Calculus.
    - Vesical neck
      - Calculus.
      - Prostatic hypertrophy.
      - Contracture at neck.
      - Bar.
      - Tumor.
  - (2) Nerve disturbances
    - Spasm of sphincters (interference with inhibition).
    - Hysteria; shock; post-operative and traumatic neurosis.
    - Masturbators and nymphomaniacs.
    - Organic nerve degenerations: tabes, paralyses, scleroses, inflammations; trauma, hemorrhage, tumor, gumma, abscess.
    - Sudden chilling of body.
  - (3) Infection
    - Interstitial cystitis, acute or chronic.
    - Bacteriuria of girls.
  - (4) Habit or circumstance
    - Voluntary or accidental.
    - Retention of clerks, teachers, etc.

Mechanical obstruction may affect any part of the urethra (narrow meatus, stricture of the urethra) or the vesical neck. A stone lodged

within the vesical outlet, a pedunculated tumor or prostatic outgrowth may produce the plugging that effects obstruction and retention. Contracture of the vesical neck and prostatic bar produce obstruction in a manner slightly different from the above. They result in "prostatism without enlargement of the prostate."

The nervous influences that bring about retention are multitudinous. They embrace both local and central affections, both transient and irremediable.

Sphincteric spasm, "stammering of the bladder," in which the patient urinates only in a series of interrupted efforts, is one of the conditions in this category, especially troublesome when the patient is excited or attempting to hasten urination while in the presence of others. In such a case a full-sized sound passes easily through urethra and vesical neck, demonstrating the absence of mechanical obstruction at any point and at the same time affording prompt relief to the spasm. The fixed ideas of hysteria, post-operative and puerperal disturbances, nervous shocks, traumatic neuroses, all contribute to vesical retention, often complete and obstinate. Female masturbators and nymphomaniacs acquire the retention habit through their desire for personal manipulation (catheterism) at the hands of physicians.[72]

Organic nervous diseases furnish the largest quota of causes for this condition. Among such may be mentioned the several forms of sclerosis and inflammation of the spinal cord and its membranes, the effect of trauma, abscess, hemorrhage, gumma or tumor of the cord, producing paralysis of the detrusors. One of my own adult male patients suffered from spina bifida, the size of a walnut. He failed to wear a protector for it and was subjected to jolts and contusions during his earlier life that, as explained by W. W. Graves, in consultation, resulted in neuritis involving the vesicospinal center. This led to obtunding of the sensibility of the nerve filaments at the periphery (vesical neck); thereafter, desire to urinate was not aroused promptly on the filling of the bladder, so that frequent overstretching ensued. Following on the persistent recurrence of the overstretching came atony and tolerance and chronic retention, with total inability for voluntary urination. While there was complete and lasting retention in this case, there was no organic impediment at any point, and the only factor that could be discovered as having a bearing was the spina bifida. There were other stigmata of neural degenerations present.

Cystitis, acute or chronic, sometimes induces retention (Layton[59]); but a condition that is sometimes more startling in its effects, and not so easily explained, is the complete retention of young girls, occurring in connection with bacteriuria. Cystoscopic examination demonstrates the complete absence of inflammatory changes or obstructive deposits; so that, while the bacterial infection is shown to be the causative factor, and indicates the direction of attack to secure relief, it is probably through nervous influences that the retention is brought about.

Marked retention and even atony, to a degree, are sometimes derived from the habit of teachers, clerks, or over-bashful young persons to procrastinate in the matter of relieving the filled bladder. One or two

repetitions of this indiscretion may not produce serious effects, but it is indubitable that repeated imposition of this sort on the bladder does serious damage.

Symptoms.—Retention is often insidious in its onset; it may be present for months before the patient or his medical attendant realizes or even suspects it. While it is a condition easily demonstrable by the use of the catheter, no thought of any such necessity presents itself; and the "treatment," meantime, consists in a varied assortment of diuretics and corn-silk preparations.

The complaints of the patient refer mainly to fullness or heaviness in the lower abdomen, frequent desire to urinate, with inability to satisfy that desire, and a sensation as of something being left over each time; prolonged or interrupted efforts at urination; and, finally, complete inability to urinate. Then appear the evident signs of the condition, as well: Distention and protrusion of the lower abdomen, globular in shape and flat on percussion. Catheterization gives immediate relief to the complaint, reduces the tumor, and withdraws an inordinate amount of urine (20 to 40 ounces), establishing the diagnosis of retention. The presence or absence of atony is determined by the same means—by the energy of the return-flow of fluid injected into the bladder through the same catheter. The emphasis of the complaint made by the patient depends largely on whether infection of the urine has yet occurred—and it is almost certain to occur sooner or later; after which the irritative symptoms are much increased.

There is sometimes confusion in the use of the terms paralysis of the bladder and atony. They indicate quite different conditions. In paralysis the inability to urinate depends on disease of the motor nerve-tracks leading to the bladder; in atony it is due to weakening or degeneration of the muscles themselves, the nervous mechanism not being affected (Casper[20]). "Paralysis of the bladder" is often used ambiguously. It requires further definition as to whether the paralysis affect the sphincters or the detrusors. If the former, there is leakage or incontinence; if it affect the detrusors, there is retention. If both systems are paralyzed, incontinence from overflow will ensue.

Treatment.—It is apparent that the treatment of retention and atony depends largely on the causative factor. With the removal of the mechanical obstruction, the infection, or the neurosis that has been present, there is usually recovery, not only from the habit of retention but also restoration of the contractility of the detrusors, with removal of the atony. But the organic nerve diseases do not offer as hopeful a prospect in this light; they are not amenable to treatment to the degree of the other causative conditions. Nevertheless, it must not be thought that retention and atony are beyond all chance of reclaim under such circumstances. The regular passage of full-sized sounds or the use of the deep urethral dilator, together with intravesical irrigations with tonic antiseptic solutions, will in many instances restore to usefulness and a fair degree of ability tabetic bladders that have been chronically burdened with from 20 to 40 ounces of infected residual urine.

For the other classes of retention, in addition to the removal of the cause of whatever nature, there are certain measures advantageous for restoring the atonic condition after the retention has been effectually done away with: Faradization of the bladder muscles, one electrode within the bladder; vibratory and other forms of massage, applied directly and also to the spinal cord; the use of strychnin in large doses, hypodermically or internally; intravesical injections of rather strong nitrate of silver solutions (1: 5000 to 1:1000); the regular use of the catheter for completely emptying the bladder, or even the retention of the soft-rubber catheter in the bladder for a time, to free it from any possibility of becoming distended—are all measures of excellent advantage.

Enuresis.—Enuresis or incontinence of urine is of frequent occurrence and is practically confined to children, affecting both sexes. Enuresis nocturna is the commoner manifestation, but diurnal enuresis also occurs. It is not a disease, but a symptom.

Incontinence is a natural phenomenon in infancy. The infant has no discretion in the premises; the detrusors take charge of the function of urination by simply overpowering the little sphincter resistance in evidence at that time, and forcibly empty the bladder when it fills. Later, the sphincter comes into strength and serves under intelligent control of the child. This is the voluntary, external sphincter for the bladder. Not until puberty does the prostate take on the development that brings into play the internal or prostatic sphincter. Hence it is that many male cases of enuresis that have been inveterate cease without apparent cause about this period of life. There are then two sphincters instead of the one previously in force.

But this does not explain the lack of retentive power in little girls. Whatever the explanation, it is probably excitability of the detrusor muscles of the bladder, aroused by various influences, that is the immediate cause of the nightly evacuation. These causative influences are multifarious and embrace, besides a neurotic disposition, many morbid conditions in either sex that act by reflected irritation from points in intimate nervous relationship with the bladder or the vesicospinal center. Among such morbid conditions may be mentioned phimosis; adhesions between prepuce and glans penis or clitoridis; narrow meatus; intestinal worms and other irritants of the lower bowel.

Treatment.—Appropriate treatment usually brings success. Naturally, it involves search for and removal of the cause; in addition to which attention to the general health and hygienic regulations must be given. Such children should be cared for especially before bedtime. They should be given a light supper, with little or no water toward evening. They are reminded to empty the bladder before retiring, and to pay prompt heed to any desire to urinate in the night—to arise at once and use the vessel; also to cultivate a habit of arising for this purpose. The covering should be light; the bed should be elevated at the foot, relieving the pressure from the lower part of the body. Medication applicable includes rhus aromatica, belladonna, and arsenic, all in full doses. Faradism and galvanism may be applied through the rectum, bladder, and

perineum. Deep urethral injections of silver nitrate, ¼ to 1 grain to the ounce, are serviceable; likewise in rare cases the passage of increasing sizes of steel sounds at intervals.

Epidural injections of saline solution were introduced in 1901, by Cathelin, for remedying incontinence and frequency of urination. They

FIG. 178.—PATIENT IN POSITION; NEEDLE BEING INTRODUCED (Hirsch).

have been highly praised for their efficiency by many authors. The method of use is as follows: The patient is bent sharply forward as he lies on his side on the table (Fig. 178). After the usual precautions of

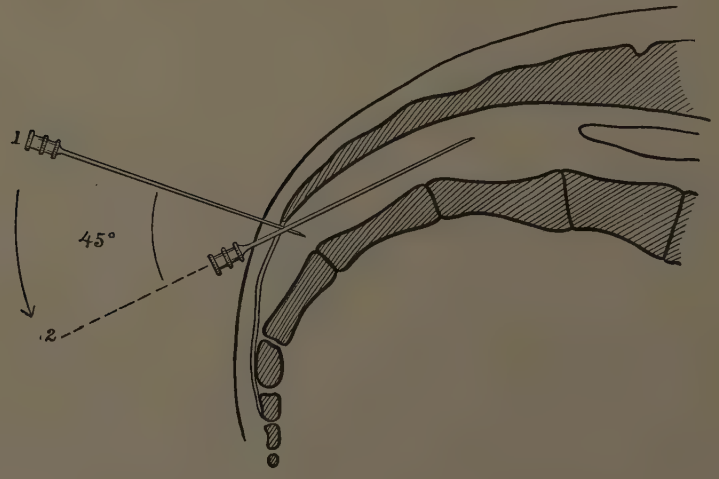


FIG. 179.—INTRODUCING THE NEEDLE (Hirsch).

cleanliness and asepsis have been observed, a hollow needle 6 centimeters long is introduced through the sacral hiatus (Fig. 179) into the spinal canal. It thus reaches the space between the periosteum lining the canal and the dura mater of the cord—well below the filum terminale of the cord, which does not descend lower than the second sacral vertebra. In

introducing the needle, a circular motion is to be executed, as shown in Fig. 179. The formula recommended is the following:

Sodii chloridi	0.2 Gm. (3½ grains)
Cocain hyrdochlorid	0.01 Gm. (⅙ grain)
Aquæ destil. steril.	100.0 Gm. (3½ ounces)

It is proper to begin the series of injections with one of 10 c.c. (2 drams) of the above, gradually increasing up to 20 c.c. (4 drams); making each injection slowly and gradually, to avoid systemic disturbance. From five to ten are given in series, three to five days apart. In a highly excitable child a moderate degree of chloroform anesthesia may be supplied.[47]

URETHRAL OR CATHETER SHOCK AND FEVER.

Excluding from present consideration the conditions properly termed urinary fever, discussed in another chapter, and confining our attention to the results of urethral or vesical instrumentation, it may be said that disturbances arising therefrom manifest themselves in three ways:

1. By shock to the nervous organism, shown ordinarily by chill, with or without fever; properly termed urethral shock.

2. Urethral chill, fever, and toxemia, arising directly from the absorption of septic bacteria or their products from the urethra.

3. Shock to the kidneys, resulting in the suppression of urine and retention of the various urinary excreta—uremia.

The first is independent of the presence or absence of urinary infection or of bacterial absorption, and appears to be purely a nervous phenomenon occurring in a nervous, susceptible individual. The other two are inseparably connected with the absorption of either pathogenic microbes or their products; such absorption coming, in certain instances, from infected urine, in others being independent of urinary complication.

Etiology.—Although the term "catheter fever" is used synonymously in this connection, it is nevertheless true that such morbid phenomena occur without urethral instrumentation; that recurrent chills and fever arise in connection with inflamed and obstructed urethras before needed instrumentation is begun. "Catheter fever" is inappropriate to designate such cases.

The absorption of bacteria or their products is most easily effected when accompanying conditions are favorable; when the urethra is strictured and the subject of chronic inflammatory processes that both decrease the power of resistance and increase the pressure of the urine which favors absorption; all of which at the same time favors the growth of bacteria and their products. The more deeply seated the urethral lesion, the greater is the liability to absorption and systemic reaction.

It is well established that extensive urethral manipulation may be carried out with impunity provided free drainage of the urethra is maintained; for instance, by adding external urethrotomy and perineal drainage to operative procedures on the urethra. Under such circumstances it is rare to observe urethral chills or fever, especially if ordinary precautions as to asepsis are taken; while, on the other hand, internal

urethrotomy or soundings unaccompanied by drainage are much more frequently followed by such reactions.

However, this factor of absorption cannot account for the purely nervous form, urethral shock, which often shows itself immediately after the instrumentation and before sufficient time for the establishment of bacterial absorption and its effects. Overpowering impression on the susceptible nervous system—shock, whatever that may be—alone can account for these.

Symptomatology.—Urethral shock or chill may be of mild or of fulminating type; so slight as to be evidenced by chill only, without subsequent fever, or so severe as to kill the patient within a few hours. And the accompanying conditions do not form an accurate guide either for anticipating such an occurrence or for prognosticating its severity or outcome. In certain instances the passage of a smooth steel sound which occasions little or no actual pain, in an individual with uninfected urine, is followed by prolonged rigor and ensuing high temperature (103° to 105° F.) and profuse sweating, with severe prostration; while in another instance rude or severe operative measures may give rise to no such consequences.

The paroxysm may be single and more or less transient, the subsequent twenty-four hours finding the patient restored to his previous condition, or it may be recurrent and merge into a condition of sepsis that reduces his health, strength, and weight. Uremic evidences may be added to these, indicating the manifestations of the third variety, ushered in by anuria, uremic odor from breath and skin, hebetude and coma, with continued high temperature.

Treatment.—Whatever may be the theoretic and pathologic differences between the several modes of origin and production of these clinical phenomena, the one fundamental observation of inestimable value that has been made by modern investigations is that they are almost invariably preventable by appropriate measures. If the high-tension, apprehensive nervous element so predominates in a patient as to render urethral shock in connection with proposed urethral instrumentation a probability, it may almost certainly be prevented by preparatory measures—by slow progress in applying the respective measures, by securing freedom from anxiety and pain through ample local anesthesia. Fear, anxiety, and pain are strong contributing factors in the production of urethral shock; so that the gradual education of the patient and his urethra to the point of tolerance of instrumentation is a means of prophylaxis of no mean value.

Since absorption of bacteria or their products is the essential factor in the other two forms, that must be the point of therapeutic attack, both for prophylaxis and relief. Prevention of such absorption may be accomplished in three ways: (1) By neutralizing the injurious elements before their absorption, *i. e.*, rendering them innocuous, by either internal or local antisepsis; (2) by washing them out of an involved urethra, before and after instrumentation; (3) by securing complete and effective drainage of the urethra.

Internal antisepsis is furthered by the administration of urotropin,

cystogen (the several formaldehyd products), salol, salophen, salicylate of soda, benzosol, quinin. Digitalis is strongly supportive and stimulating to the kidneys. Local antisepsis and asepsis are best secured by copious and frequently repeated irrigations of the whole urethrovesical tract with solutions of the citrate or nitrate of silver, argyrol, boric acid, sodium chlorid (neglected but efficient), salicylic acid, or potassium permanganate.

It is ordinarily better to make the irrigations by the Janet method, by hydrostatic pressure from the meatus, rather than by introducing the catheter. In this way the urethra receives a double irrigation under pressure, permitting the postponement of the introduction of any instrument until sufficient preparation has paved the way to tolerance.

Where urinary obstruction and retention are prominent it may be desirable to introduce a soft-rubber catheter of good size and retain it in urethra and bladder for several days, by means of zinc oxid adhesive plaster.* Still more thorough drainage, required in some cases of extreme debility or in which it is impossible to introduce a catheter, is attained by perineal incision and the introduction of a large double drainage-tube, or two rubber catheters tied together, furnishing the channel for continuous in-and-out flow of saline solution. This plan is of inestimable value in tiding a depleted and septic patient over a critical period in the presence of vesical stone or prostatic obstruction, in which it is desired to accomplish the radical operation by stages, such drainage being the first and preparatory stage. It at times reclaims patients who appear to be on the verge of dissolution.

The routine practice of following all urethral manipulations with antiseptic irrigations is highly commendable. Few surgeons of long experience have failed to note the gratifying decrease in "urethral chills" that has occurred in their work after the adoption of this plan.

It goes without saying that infection must not be contributed to urethras by unclean catheters or sounds.

CYSTITIS: INFLAMMATION OF THE BLADDER.

With the premise conceded, that inflammation of an organ is invariably caused by microbic invasion of that organ,† the modern interpretation of the status of cystitis in pathology is readily understood. That is: All cases of cystitis are caused by bacterial infection; and all other factors that have a bearing on the etiology do so from the standpoint of predisposing cause only. This presupposes a distinction between irritative symptoms mimicking cystitis (as in a transient irritation) and actual inflammation of the bladder.

With this understood, the causes of cystitis may be classified as pre-

* This mode of retaining a catheter is less complicated and more efficient than by means of any of the apparatus devised for the purpose. It consists in running strips of the plaster from each side of the penis down onto and around the catheter, afterward reinforcing these with others encircling the penis. The latter must be wide enough not to constrict or interfere with the circulation.

† In Vol. I, p. 185, Adami says that micro-organisms are the direct cause of inflammation in the majority of cases. "With rare exceptions they form the direct cause of all the serious cases of inflammation in which surgical intervention is demanded."

disposing and exciting, the latter being the various kinds of bacteria that furnish the infection; the former being the several conditions and influences that contribute to the establishment and growth of the organisms in the bladder.

Predisposing Causes.—The most frequent of all predisposing causes is retention of urine. This furnishes the condition *par excellence*, as Guyon has pointed out, inviting the settlement and propagation of microbes in the bladder, and conducing to their pathogenic activity after they are established in this most favorable habitat.

It has been experimentally demonstrated that microbes thrown into bladders free from obstruction or retention are readily washed out in the course of regular urination, and no infection results; while if the same bladders be subjected to the same treatment, with the additional provision of obstruction to the escape of urine from them, effected in any manner, they promptly undergo infection and respond to the usual course of such infections.

Retention is an attendant on many of the predisposing causes; it is often induced by the presence of vesical stone, vesical tumor, prostatic hypertrophy, and in each instance exercises its malign influence in inviting the infection that establishes the inflammation.

Foreign bodies likewise contribute to the setting up of infection by inducing a *locus minoris resistentiæ*, where microbes find fertile soil for their establishment and propagation. This condition is arrived at through disturbances of circulation and nutrition. Similar localized depleting influences come from changes in the urine that render it injurious to the vesical membrane, through hyperacidity or alkalinity; and morbid chemical, thermal, and toxic influences contribute to the same end. Cystitis from "taking cold" can only be interpreted in this light as a possible cause.

Exciting Causes.—These are constituted by the several varieties of bacteria that attack the walls of the bladder, and it has been determined that all microbes that possess pyogenic properties must be included.

Modes of Entrance.—While, without doubt, the most frequent of all these is the introduction of the organisms in the course of instrumentation, whether carried into the bladder on an infected instrument or from an infected urethra by a clean instrument, there are other ways by which the same result is accomplished. These include descending invasion from ureters and kidneys (either by continuity of surface or by the urinary stream), ascending invasion from urethra, prostate, epididymes, vasa deferentia, or vesiculæ seminales (continuity or contiguity), or solely by contiguity, from adjacent infected organs, such as pus tubes, the colon or rectum.[121, 93]

These numerous avenues of contagion speak volumes in explanation of the proneness to recur of cases of bacteriuria and other sequences of colon bacillary infection.

The healthy urethra is the customary habitat of several varieties of bacteria; Lustgarten and Mannaberg,[71] in examining eight supposedly healthy urethras, found ten varieties, several of which were deter-

mined to be capable of producing cystitis. This fact explains the impossibilty of rendering the urethra wholly sterile or of attaining absolute immunity in urethral and vesical instrumentation, by present methods of preparation.

That the urine, though macroscopically clear and limpid, may be the vehicle for carrying infective organisms into the bladder, is proved by the numerous instances in which such urine has been found to contain typhoid bacilli;[8] and cases of cystitis in which this bacillus was the only one demonstrable are also on record.[50] The urine has performed the same office for other kinds of organisms as well.

While it is true that practically all pyogenic bacteria have been identified as causative of cystitis, certain ones are more prevalent in that light, notably the colon bacillus. This is the instigator of the great majority of all non-tuberculous cases of cystitis; while it is also the principal pyogenic factor in most of the cases of mixed infection and of tuberculous infection. Staphylococci and streptococci are next most frequent. Gonococci have had a reputation in this regard that is not borne out by the facts. Their ability to invade the bladder is usually limited to the neck of the organ. The invasion of the bladder that follows urethral gonorrhea is of the mixed variety, the gonococci paving the way for the entrance of the other organisms that involve the bladder in inflammation. In passing from the posterior urethra to the ureters and pelves of the kidneys, the transition of gonococci is made through the submucous lymph-channels rather than via continuity, along the vesical mucous membrane.

Classification.—Cystitis may be classified according to (*a*) the anatomic location; (*b*) the clinical manifestation; (*c*) the pathologic process.

With regard to its anatomic location it may be subdivided into: (1) superficial; (2) interstitial; (3) perivesical inflammation.

The least severe of these is the first-named, sometimes also called catarrhal. It displays a predilection for attacking the neck, the trigone, and the membrane in the immediate neighborhood of the ureteral orifices. It requires a somewhat aggressive attack to generalize this variety; and in such instances it is liable to merge into the second-named, or interstitial cystitis. Under such circumstances the structure of the bladder-wall is involved, in addition to the mucous membrane; and there are swelling and thickening of the affected parts, with contraction of the vesical capacity, sometimes to such a degree that the organ is able to hold only an ounce or two of urine.

In both of these forms the inner aspects of the bladder become changed. The normal salmon-pink of the membrane, especially at the trigone and the neck, gives place to diffuse redness; the blood-vessels are no longer discrete and separable into their several twigs and branches, but are swallowed up in the diffusely reddened, edematous, and often ecchymotic areas. The membrane loses its glistening luster and becomes rough or velvety in appearance. The folds of the mucosa become prominent.

In the third form, or perivesical inflammation, the connective tissues adjacent to the organ and also its peritoneal covering are the parts

involved. The peritoneal implication results from extension of a similar process from some neighboring organ, the uterus, tubes, ovaries, or appendix. The loose connective tissues of the prevesical space (of Retzius) are the most common focus for the development of pericystitis, a frequent outcome of which is prevesical abscess.

Clinically, cystitis is divisible into acute and chronic forms. Based on the character of the inflammatory process, it is divisible pathologically into (*a*) catarrhal; (*b*) suppurative; (*c*) ulcerative; (*d*) exudative; (*e*) exfoliative cystitis (Senn[103]).

The immediate effect of microbic attack on the bladder-structures varies according to the variety of the causal microbes, the virulence of their activity, and the influence of accompanying conditions (obstruction, etc.).

Catarrhal Form.—This refers to superficial inflammation, in which epithelial elements, rather than pus, are the principal inflammatory product; in contradistinction to the next, the—

Suppurative Form.—In this there is, in addition to the more superficial attack, an infiltrating inflammation (interstitial), with much pus in the urine, large and small epithelia, leukocytes, and red cells. Fibrinous patches appear on the inflamed surface, becoming necrosed if the urine remains strongly ammoniacal.

Ulcerative cystitis refers not to cases in which there is the addition of ulceration to the above-mentioned form, but to those in which ulcers appear at the outset, possibly singly, as is indicated by the term "simple ulcer of the bladder," analogous to ulcer of the stomach. Fenwick[31] reports having seen several such cases. While the symptoms may not be severe in this form, they are inclined to be persistent. The ulcer is the result of an infection from the blood, the inflammation attacking the tissues around an infected embolic infarct, reaching the surface by process of ulceration (Senn[103]).

Exudative cystitis is accompanied by the deposition upon the inflamed surface of the products of coagulation necrosis. It occurs in puerperal women, and is then indicated by the expulsion of membranes or shreds of fibrin with the urine.

Exfoliative Cystitis.—Apparently from the effect of toxins, the mucous membrane of the whole bladder is destroyed and cast off in the form of a mold, perhaps as one piece. If broken up it may pass out in the urine; but it may, as a coherent mass, block the urethral outlet and require extraction at the hands of a surgeon. A number of such cases are on record.[107, 52]

Bacteriuria.—This is a condition that is closely allied to cystitis, in that infective organisms (habitually, colon bacilli) infest the urine to a degree of dense clouding, but without producing any pathologic changes in the bladder-walls themselves; in fact, the bladder participates in no other way than by acting as a receptacle for the infected urine. In such cases, the source of infection is ordinarily the lower bowel, constipation serving to precipitate a flood of colon bacilli into the bladder directly through the intervening tissues at irregular intervals.[39, 58]

Symptomatology.—There are no pathognomonic symptoms of cystitis, and differential diagnoses cannot be arrived at by the symptomatology. The prominent symptoms of this affection also serve as indications of other urinary maladies (see General Remarks on Diagnosis, page 272).

Only one sign, pyuria, is constant; the others, though characteristic, are variable. They are: frequency of urination, urgency, pain, and hematuria.

Normal inclination to urinate is aroused by the passage of the urine from the filled bladder into the prostatic urethra, irritating the mucous membrane of that part. This indicates that it is *irritation of the prostatic urethra* (which is the vesical neck, after the opening up of the internal sphincter) *that causes the desire to urinate.* Inflammation constitutes such an irritant, but only if it is applied at this point, the vesical neck; and that is the case, whether the irritation is applied directly or reflexly. Inflammation or ulceration of the wall of the bladder does not, *per se*, tend to arouse frequency; whereas inflammation at the neck displays that tendency to such a degree that stamps frequency as one of the most prominent and characteristic indications of disease at this point.

Urgency, likewise fairly constant in its attendance on the disease, arises from a similar cause: the inflammation attacking the neck. With the bladder moderately full, no urgency is felt; but immediately the urine passes into the prostatic urethra on filling the bladder, the imperative impulse to evacuate the bladder is felt and there can be no hesitation in giving it attention.

Pain in connection with cystitis may be fairly constant or intermittent, spontaneous or aroused by pressure. It is usually more marked when the organ is filled with urine, but if there is stone, the pain may be especially acute at the end of urination, from pressure of the inflamed membrane on the calculus. Pain is referred to the suprapubic and perineal regions or the rectum, and is sometimes thought to be in the bowel. It is often associated with tenesmus.

Hematuria.—With cystitis there is excitation of the muscular apparatus, both detrusive and sphincteric. When these act counter to one another, there is straining of the detrusors to overcome the obstructive effect of the sphincters, the result being extrusion of blood from the congested and inflamed membranes. It appears either as drops of blood after urination or as numerous blood-cells in the urine.

Pyuria.—The pus of cystitis clouds all of the urine, whether it is taken in one, two, or more glasses. The clouding is intensified by epithelia, blood-cells, and hordes of organisms that find the urine a fertile soil for their growth. The thorough diffusion of the clouding in this affection is in contrast to that of pus from renal or pelvic inflammation. Here the pus rapidly settles to the bottom of the glass, making a thick belt of sediment with sharp demarcation from the comparatively clear urine above it. The flakes of pus and mucus of cystitis may be observed either by the naked eye or the microscope.

Reaction.—In acute cases the urine may be either acid or alkaline,

but in the chronic ones, except where the origin is tuberculous, the reaction is liable to be strongly alkaline; and with continuation of this condition the urine becomes thick and ropy with muco-pus, from ammoniacal decomposition.

Diagnosis.—All of the above indications are of value in centering the attention on the bladder as the possible seat of the trouble, but they do not fill the requirements for differentiation or for excluding the renal pelves or the ureters from participation in the infection. This is best determined by means of the cystoscope. While in some quarters fear exists as to the permissibility of using this instrument, more especially in acute cases, that view is not held so much by those who have cultivated its use as by those to whom it is unfamiliar. Much valuable time is lost in many instances by depending on insecure and inefficient methods of differentiation. The blame for many a chronically inflamed or even destroyed kidney may well rest on belated diagnosis and indefinite treatment. The moderate additional pain or excitation incident to cystoscopy or ureteral catheterization, as now practised, is more than discounted by the therapeutic advantage derived from locating infection in one or both renal pelves and annihilating it there.[64]

Cystoscopy demonstrates the presence or absence of the various local changes occurring in the vesical membrane, and serves an invaluable purpose in estimating their seriousness, their extent, and their pathologic characteristics. By it the exact source of active vesical hematuria is determined, or the possibility of stone or foreign body as a contributing factor is decided. Catheterization of the ureters can alone be relied upon for arriving at the points of differentiation with regard to infection of the upper urinary tract;* and it affords not only this advantage, but offers the only opportunity for direct treatment of ureters and pelves by antiseptic irrigations and instrumental manipulations.[62]

Prognosis.—Cystitis is so intimately connected with and often dependent upon other accompanying conditions that its prognosis can be estimated only when these are given due consideration.

While vesical stone does not directly cause cystitis, its bearing, once infection is accomplished, is such that no hope of eliminating the infection can be entertained until the stone is removed; after which the problem of relieving both infection and inflammation may be comparatively simple.

Aside from its association with such inveterate conditions as stone, stricture, prostatic hypertrophy, etc., the prognosis of acute cystitis is favorable; and it is still favorable when these are given first attention in the therapeutic plan.

In chronic cystitis the prognosis is not so good because of the secondary changes which the bladder is liable to have undergone; such as atonic dilatation, atheromatous degeneration, or contraction. If such changes have not gone too far, however, it is yet possible to look for complete recovery after removal of the predisposing cause and annihilation of the exciting infection.

* For discussion of segregators, see page 279.

On the other hand—and this is one of the most important points of the whole subject—with continuation of the predisposing causes, such as the obstructions mentioned, not only is the cystitis assured in respect to persistence, but involvement or destruction of other organs may be expected. Infected and dilated ureters, pelves, and kidneys are constant and destructive followers of cystitis in which retention and backward pressure are dominating features; and they place such patients beyond surgical reclaim. The large number of "beautiful specimens" of sacculated kidneys, mere urinary pus-sacs, to be found in pathologic collections, furnish mute but eloquent testimony of opportunities and life sacrificed on the altar of procrastination, of incomplete diagnosis, or of unreasoning fear on the part of patients of the word "operation."

Treatment.—The treatment of cystitis may be divided into prophylactic and curative; general and local; palliative and operative.

Prophylactic measures are to be adopted when conditions favorable to the establishment of infection are known to exist. Attention given to hygiene and the general health will, under such circumstances, often prevent recurrent attacks or lessen their severity if unavoidable.

Regulation of both urinary secretion and the alimentary tract is highly important. Constipation and indigestion show their deleterious influence directly they occur, and morbid urine, either in respect to concentration or reaction, has an equally prompt effect for injury. Water should be taken freely; it assists in the functionation of both these tracts. Exercise is objectionable and must be avoided as far as possible. Patients often make the mistake of resting for a time, and then throw away the good accomplished by it by lifting some heavy weight or running for a car. Horseback-riding and bicycling are likewise to be avoided. The skin should be kept active by baths and rubbings.

Local prophylaxis, so to speak, refers especially to the avoidance of introducing infection into the bladder, also adopting measures to protect the organ as far as possible against such introduction. It relates to asepsis and antisepsis with respect to the urinary tract, the use of sounds, catheters, and treatments. It is explained at greater length elsewhere.

Curative treatment is local and general, operative and non-operative. It necessarily presupposes the detection and removal of all contributing or predisposing causes, such as urethral stricture, stone, prostatic hypertrophy, or vesical tumor. Attempting to cure cystitis without first attending to such militating conditions is like the task of Sisyphus, a never-ending one; the stone rolls back again as soon as it is pushed to the top of the hill.

General curative measures embrace the administration of the internal antiseptics of the salicylic and formaldehyd groups: salicylate and benzoate of soda, salol, salophen, salipyrin, benzosol; cystogen, urotropin, helmitol; quinin; extract of couch grass and of corn-silk; santal oil. Isolated or in proper combinations, these are all excellent remedies. It must be observed, however, that in certain cases the formaldehyds tend to irritate the kidneys. When this effect is perceived they should at once be withdrawn.

In very acute or severe cases the use of the narcotics and nerve sedatives is extremely serviceable. Morphin or anesthesin and belladonna suppositories afford relief that is both prompt and of curative influence. Unceasing efforts at urination are in themselves highly injurious, and should be relieved as soon as possible.

The diet should be simple and light; stimulating foods must be interdicted. These include spices and strong seasonings, asparagus, radishes; the red meats (beef, mutton, and pork), salted meats or fish; alcoholic drinks and tobacco. The cereals, most vegetables, the white meats of

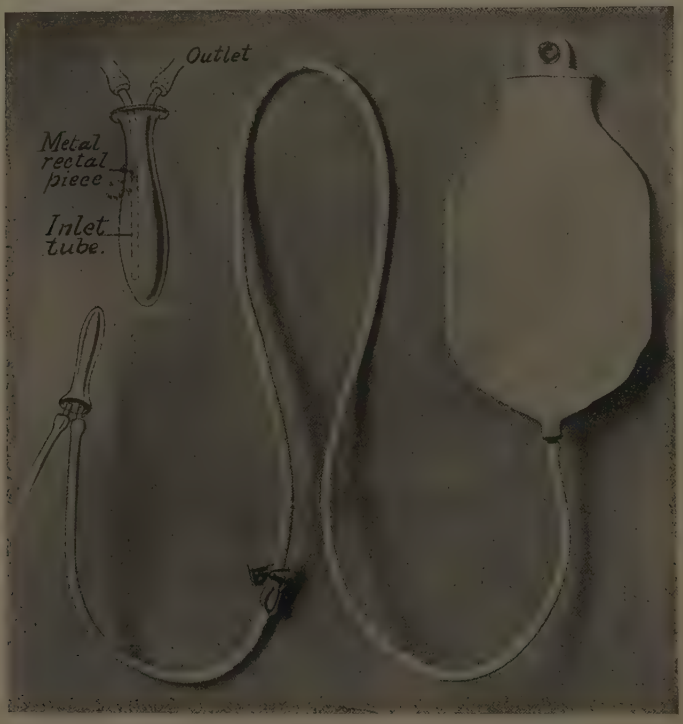


FIG. 180.—AUTOMATIC SELF-RETAINING RECTAL SIPHON.

poultry and game, fish, sweetbreads, frog legs, brains, milk, and the bland waters, uncarbonated, are to be favored.

Absolute rest in bed for a few days will be found of marvelous benefit at times, and especially if advantage is taken of the opportunity it furnishes to make use of various local measures adapted to the acute process. Chief of these is heat applied in various ways: stupes or fomentations to the suprapubic region or the perineum; the hot siphon (Fig. 180)* (112° F.) into the rectum for fifteen minutes at a time; and hot sitz-baths.

As a general rule, in acute cystitis it is best not to resort to intravesical injections or washings until the internal, local, and hygienic

* One made for myself is self-retaining, and is equipped with appropriate bag and tubes to make the use of it automatic.

measures have reduced the severity considerably; after which it is proper gradually to begin the use of bladder-washes, with the mildest and most soothing of antiseptic solutions. The best of these are boric acid, sodium chlorid, argyrol, and fluidextract of hydrastis. Later, the stronger antiseptics may be employed, such as permanganate of potassium (1 : 5000 to 1 : 1000); citrate and nitrate of silver (1 : 5000 to 1 : 500); oxycyanate of mercury (1 : 10,000 to 1 : 5000); carbolic acid (1 : 1000).

The proper execution of the bladder washing is of the first degree of importance. All fluids thus used must be distinctly warm or nearly hot, adding to their acceptability and effectiveness. Instrumentation in acute cystitis is to be avoided as far as possible; therefore it is preferable to introduce the solutions by hydrostatic pressure (the method of Janet) and without the introduction of a catheter. By having the patient relaxed, in a reclining posture, the fluid quite warm and at only moderate elevation (two or three feet), it is nearly always possible to overcome the natural resistance of the vesical sphincters and to pass from four to six ounces of the solution into the bladder before the patient announces the feeling of distention. This should always be a sufficient signal for stopping the in-flow; to carry it further than is comfortable for the patient is to use bad judgment. It will only cause injury. Diplomacy is immeasurably better than force in all of these maneuvers.

If it be found difficult to get relaxation of the sphincters with moderate elevation, it is advisable to inject 15 minims of a 2 per cent. solution of cocain or alypin, following with air-pressure to advance it to the compressor urethræ muscle for a minute or two; after which the irrigating fluid will usually enter without the slightest difficulty. If the capacity of the bladder is much reduced, the ten or more ounces may be introduced in broken doses, two or three ounces at a time.

In chronic cases, or those in which there is marked retention, with the collection of quantities of pus and mucus, it is necessary to use a catheter, both for its cleansing effect and for the relief of the retention. The procedure is repeated once daily; later, every second or third day.

If the infection is of gonorrheal origin (mixed infection, as it then becomes in the majority of cases), it is not always advisable to await the subsidence of the acute symptoms before beginning the irrigations. If well borne and containing the proper medicament, these may afford prompt benefit or relief. In the instance mentioned, two drugs in particular have given me great satisfaction—argyrol and permanganate of potassium. The former is without irritating effects and yet is markedly germicidal; the permanganate is more inclined to give temporary irritation, but its after-effects are often highly gratifying in the mixed infections.

But certain cases in subsiding from the acute merge into a subacute or chronic form of cystitis, or prove rebellious through exacerbations and recurrences. One of the most efficacious means attainable is the use of the soft *catheter à demeure*, retaining it in the bladder by means of adhesive strips, as described on page 307. This not only affords surgical rest to the bladder by constant drainage, but gives opportunity for frequent

irrigations of the organ without successive re-introductions of the catheter, where that is found necessary. The retained catheter is well borne in a much larger proportion of cases than is appreciated by the profession. It is often equally as serviceable as the much-praised suprapubic or perineal drainage, secured only by operative measures. If the retained catheter is not well supported it is sometimes possible to remove the difficulty by stretching the posterior urethra with a Kollmann dilator, up to 38 or 40, French, under efficient local anesthesia.

If it is still impossible to make use of the retained catheter, after the adoption of this and other alleviating measures, drainage through a perineal incision is to be considered reliable. It at the same time permits the application of stretching, incision, or electrocauterization to the neck of the bladder, as may be found desirable.

TUBERCULOSIS OF THE BLADDER.

Tuberculosis of the bladder is supposed to occur either primarily or secondarily, but, as a matter of fact, it is seldom seen as a primary affection; it is so invariably in association with tuberculosis of other organs, and more especially those of the genito-urinary system, that it can hardly be studied independently of them.

The non-absorptive mucous membrane of the bladder is more resistant to infection than that of other genito-urinary organs, which may have a bearing on the fact that the vesical infection is nearly always secondary to that of the other organs. But, on the other hand, the liability of the bladder to ultimate infection is almost assured by reason of the fact that the bladder stands in the path of the flow of secretions of the body—from the kidneys downward, and from the testes upward. If either of these two sources become involved (as is frequently the case), infection of the bladder is almost a natural follower, for the reason mentioned.

Tuberculous infection of the bladder is accomplished, (1) through the blood-channels; (2) through the lymph-channels; (3) by means of the secretions (the urine, semen); (4) by continuity; and (5) by contiguity.

The mode of accomplishing the infection has much to do with the location and early manifestations of the disease. If the bacilli are inoculated by way of the blood-vessels, their seat of development is liable to be within the walls of the bladder, apart from the trigone. If they are carried down from the kidneys in the urine or along the mucous surfaces of the ureters, their point of election is apt to be the immediate neighborhood of the ureteral orifice on the side affected. If carried to the bladder, either through the lymph-channels from above, or from the testes below, via the semen and prostate, the point of election is the trigone. The course and symptomatology of the disease are much influenced by these conditions. Relatively, the trigone and ureteral orifices are most frequently affected at first; with subsequent gradual spreading by continuity and through the lymphatics to other parts of the organ.

The local evidences depend on the stage of the process. At first they may consist only of localized congested areas; then the development of

tuberculous nodules, which assume a whitish appearance and afterward break down into small, rounded ulcers, surrounded by inflamed membrane. The ulcers show a tendency to coalesce, yet do not lose their rounded appearance (Coplin[16]). The floor of the ulcer is uneven and is often covered with a yellowish-gray membrane; it bleeds easily; its edges are sharply cut or undermined. The membrane loses its luster and becomes roughened or velvety.

Mixed infection does not remain long absent from such an inviting field; and when it enters, adds its influence for diffusing the inflammatory process.

The bladder becomes contracted and reduced in elasticity and capacity, unable to receive or retain its usual quantity of urine.

Symptoms and Signs.—While it has not yet been definitely proved, it is my own belief that one of the earliest prodromes of urinary tuberculosis is the persistent appearance in the urine of red blood-cells in microscopic quantity—covering a period of years, perhaps, before the disease reaches a stage which introduces its clinical features, or changes to a macroscopic hematuria. Bloody urine is one of the frequent accompaniments of the later stages of the affection.

With regard especially to vesical tuberculosis, undue frequency of urination may be said to be one of the most characteristic and persistent symptoms. This may become noticeable long before the secondary infection clouds the urine, and before marked manifestations of tuberculosis are observable. The undue frequency means irritation of the vesical neck, either reflexly or by direct involvement of that part of the organ in the tuberculous inflammation. Where the lesions are confined to the vault of the bladder, frequency may be deferred until quite late in the disease.

Pain in the bladder and the neighboring organs is one of the most marked and characteristic features of vesical tuberculosis, especially of the later stages. Few such patients reach a lethal end without becoming addicted to the use of morphin. The pain, sometimes spontaneous, sometimes excited by urination only, is referred to the neck, the perineum, the urethra, or the glans penis. It increases in harmony with the exposure of tissues by spreading ulceration or inflammation.

The urine, before secondary infection, may be clear and limpid, increased in quantity; and unless a searching microscopic investigation, after sedimentation, be made, it may afford no assistance in explaining the urinary symptoms of which the patient complains. This is the period in which the persistent appearance in microscopic quantities of red cells in the urine should arouse the suspicion of impending tuberculosis; at least it should put the practitioner on his guard and lead him to detect the positive indications as soon as they appear.

Later, the urine, while remaining acid, becomes clouded and purulent from secondary infective changes, and shows shreds and strings of mucopus, and particles of blood-clots. It also becomes frankly bloody, intermittently or persistently.

The general health deteriorates with the progress made by the local and general tuberculous processes.

Diagnosis.—The deciding factor for proving the existence of tuberculous cystitis is the demonstration of tubercle bacilli in the urine, together with observation of tuberculous processes (inflammatory or ulcerative) in the bladder by means of the cystoscope.

While it would be farthest from my own intention to advocate meddlesome instrumentation in cases of vesical or urinary tuberculosis, my experience does not lead me to participate in the exalted fear of applying local measures, either for diagnosis or treatment, as expressed by many writers on this subject. The continuously favorable progress of a number of such cases, in which local measures have been repeatedly made use of during several years, has convinced me that this danger has been much overrated.

Tubercle bacilli are not always to be found in urinary tuberculosis. It requires ulceration at some point to release them and supply them to the urine. But even then, unless properly looked for, they may escape detection for an indefinite length of time. They should be looked for only in the freshly passed urine, as it is probable that they decompose on standing, especially if the urine undergoes alkaline decomposition. Being of light specific gravity, they require strong sedimentation to drop them to the bottom of the centrifuge tube. Bryson called attention to the fact that they are more liable to be found in the small quantity of urine left over after voluntary urination, this last amount being taken by a soft catheter and immediately sedimented.

If tuberculous infection be suspected but be incapable of demonstration, the sediment of the suspected urine may be inoculated into a healthy guinea-pig, the result of which furnishes very reliable testimony as to the infectiousness or non-infectiousness of the urine. Such urine should be drawn aseptically from the bladder.

While the microscopic and cystoscopic demonstrations mentioned establish the existence of tuberculous cystitis, that does not comprise all the necessities in respect to diagnosis, as it is still incumbent on the diagnostician to inquire into infection of other parts of the body, and more especially of the kidneys, a matter not to be considered here, however.

Treatment.—In addition to the hygienic influences always advantageous in tuberculous affections, the treatment of cystitis of this nature may be divided into palliative and operative, general and local.

From the writings of many authors, it would seem that local curative measures should receive but scant attention or should be avoided, and dependence should be had on change of climate and the use of general supportive measures. It is fortunate that the cloud of pessimism that has dominated this subject is lifting, and that the feeling of helplessness participated in by both the profession and the people is being replaced by a much more hopeful one.

It is true that the medicinal solutions, such as nitrate of silver and permanganate of potassium, ordinarily beneficial in vesical inflammations, do more harm than good here, but it is also true that iodoform emulsion, with some bland oil as a vehicle (one dram to the ounce of liquid vaselin,

PLATE VII.

Ulcerative Tuberculous Cystitis (Casper)

Leucoplakia of the Vesical Membrane (Casper).

a

b

Constriction of Ureter Orifice with Ballooning of the Prolapsed Ureter at Each Effort at Evacuation (Peristaltic Contraction) (Casper).
a, Shows the ureter quiescent; *b*, shows the same distended.

or oleolene), is not only soothing to such a bladder, but displays marked curative influence. Such an emulsion may be injected through a small soft-rubber catheter, or even without a catheter, by means of a four-dram penile syringe, once daily, two or three drams at a time. It should be allowed to remain as long as possible afterward; and the patient may be instructed to refrain, in urinating, from completely emptying the organ. Gomenol oil, a preparation of eucalyptus in pure olive oil, is also soothing and beneficial at times. The occasional use of boric solution as an irrigation, where there is active secondary infection, is gratefully received.

The internal use of the formaldehyd group of medicaments has little application in this association, but creasote and guaiacol, in full dosage, act well occasionally. They may be used in conjunction with other appropriate general tonics. Salol and the salicylates are of some service where there is secondary infection. Cod-liver oil is still much esteemed by many when it is well borne. Included in the hygienic influences advisable, should be plenty of fresh air, but avoidance of prolonged or active exercise; while abundant nutrition should be given (see Surgical Tuberculosis, Vol. I, page 630).

With some diffidence, in preliminary notes in one or two of the journals in 1903–04, I called attention to some rather surprising effects I had observed in connection with the use of air for cystoscopy in tuberculous bladders. Instead of the repetition of air-cystoscopy being followed by increase of the symptoms and the local evidences, in a number of instances it was followed by steady improvement in all respects. It must be admitted that iodoform injections were being used regularly during the same period. Nevertheless injury did not follow the manipulations, and improvement (even permanent relief, in certain instances) did follow them. The question is, whether the air used in the bladders did not exercise a beneficial influence in a manner similar to that recognized for tuberculous peritonitis, in which many cases are recorded as permanently cured by simply opening the peritoneum and allowing air to get to the affected membrane. It would seem to be a matter worthy of further attention, at least.

Until lately it has been the custom to reserve surgery as a last resort in vesical tuberculosis; but sentiment has been undergoing change on this subject also. In obstinate ulcerations Guyon advocates direct access to the parts by suprapubic incision, the vigorous use of the curet, and the application of bichlorid of mercury solution, 1 : 1000, by means of a swab; with subsequent drainage, for a time. The modern forms of cystoscope have afforded less radical means of access to effect the same purpose; and Garceau[35] has reported a number of cases in which he has derived excellent results from the use through the cystoscope of direct applications of both the bichlorid of mercury and the nitrate of silver. General narcosis preceded the treatment.

Based on experience with nephrectomy in connection with unilateral tuberculous kidney and secondary vesical tuberculosis, removal of such a kidney was advised with the expectation that it would be followed by restoration of the bladder to health; but later observations have led

to still more radical conclusions: that even though both kidneys are infected, one badly and the other slightly, the removal of the worse one is likely to be followed by desired relief to the bladder, if not also to the other, less afflicted kidney.

Artificial drainage may become a necessity in the later, ulcerative stages with unceasing pain. In that case it is advisable to make the incision through the vagina, in the female, and suprapubically in the male.

VESICAL HEMATURIA.

Hematuria being but a *sign of some disease*, the chief interest pertaining to its study relates to the diagnosis of its source and its cause, appropriate therapy depending largely on the correct solution of these two questions.

Causes.—It arises from either general or local causes. Since the general causes involve bleeding from other urinary organs as well, it is not necessary to more than mention them here. They embrace the dyscrasias coming from purpura, hemophilia, scurvy, malaria, yellow fever, cholera; and the toxic influence of chemicals absorbed in various ways, such as turpentine, cantharides, and poisonous anilin dyes. Lichtenstern[67] reports hematuria in workmen living under such influences.

For *local causes* of vesical hematuria Davis[24] has presented an excellent classification, as follows: (1) Circulatory disturbances; (2) trauma; (3) infection; (4) new-growth.

Vesical hemorrhages from circulatory disturbances are such as occur in connection with varicosity of the membrane[25] or passive congestion from other causes, such as hepatic cirrhosis[57]; also the condition, not unusual and sometimes very dangerous, incidental to obstructive prostatic hypertrophy of long standing, in which a catheter is passed and all the contained urine is drawn off at once. This removes the accustomed counterpressure from the membrane, inducing severe passive congestion of the whole urinary tract, hemorrhage, perhaps suppression of urine, and death.

Trauma.—Injuries, direct or indirect, may produce vesical hemorrhage. Rough or forced catheterization, the mechanical effect of foreign bodies, including calculi, are instances of the first-named; while any external violence transmitted to the bladder may be included in the second. Kicks or falls, producing contusion or rupture, are instances in point.

Infection.—Tuberculous and other forms of infection lead to inflammation or ulceration and are prolific causes of hematuria. But when thus produced, hematuria is not liable to be severe; it is often only microscopic in amount (see Vesical Tuberculosis). Aside from the bacterial infections, the parasites, filaria sanguinis and distoma hematobium, occasion the same condition in tropical countries, fortunately not in our own.

New-growths.—Tumors habitually furnish the most severe degrees of vesical hemorrhages, papilloma and carcinoma being especially disposed in this way. Vascularity is the prominent feature of such growths, and the friability of the structure leads to its breaking down and bleeding. Under

such circumstances, with cystoscopic assistance a continuous stream of blood may be seen issuing from the wall of the bladder. Such bleeding occurs independently of activity or exercise on the part of the patient, and may begin either at night or in the daytime.

Diagnosis.—While there are fairly characteristic features pertaining to the different causes of hemorrhage from the bladder, the study of these is more interesting than practical, as the one thing to do is to resort as early as possible to the use of the cystoscope. This means will lead more directly than any other to a solution of the two questions involved, *i. e.*, the source and the cause of the hemorrhage; and will also give the most direct clue to appropriate therapy. The *treatment* of hematuria is considered under the discussion of the respective conditions in which it occurs.

TUMORS OF THE BLADDER.

Tumors of the bladder formerly had little recognition as such from clinicians, but modern methods of investigation and instruments of precision have rendered possible the diagnosis, and surgery has done much to make the advance of practical benefit.

Classification.—Vesical tumors have been divided into benign and malignant; but sequences of the clinic show that such division is not always tenable; that so-called benign tumors commonly exhibit an almost inevitable tendency to recur and finally to merge into a definitely malignant growth. Küster's classification, quoted by Davis,[23] is probably the most practicable for the present:

1. Epithelial group	Papilloma. Carcinoma. Adenoma. Cysts (dermoid).
2. Connective-tissue group	Sarcoma. Myxoma. Fibroma. Angeioma.
3. Muscular group	Myoma.

Clinical observation has taught that tumors of the bladder affect males almost three times as often as females; that they are especially prone to occur, primarily, in the proximity of the ureteral openings and the trigone. Secondary tumors are engrafted at other parts of the bladder from contact with the original growth when the bladder is empty. Sarcomata manifest themselves particularly in childhood; papillomata, in middle life; carcinomata, after forty-five. Sarcomata are exceedingly rapid in their growth, attaining a large development within a few weeks; while the remainder vary from a very slow growth to a moderately rapid one.

Local Characteristics.—As a general rule, malignant tumors tend to infiltrate the bladder wall, and extend by further involvement of the wall; so that their extirpation necessarily demands the coincident removal of more or less bladder-structure. Those of the so-called benign type tend more to pedunculation, and their growth is in the direction of least resistance, *i. e.*, into the bladder cavity; their removal, therefore, requires less radical methods than the other.

The pedunculated, polypoid tumors vary from soft, filmy, fimbriated masses floating in the fluid, as seen by the cystoscope, to firmer, cauliflower-like bodies, attached to the bladder wall by pedicles of greater or less size. They are freely movable within the cavity.

The opposing type present the sessile appearance, with broad attachment and involvement of vesical structure; of rugged, ulcerated surface, with gaping fissures, from which blood may be oozing at the time of observation. These growths are not only immovable in themselves, but they change the vesical walls into a dense mass of board-like hardness, often palpable through the rectum or the abdominal wall.

Symptoms.—The earliest, most enduring, the most characteristic symptom of tumor of the bladder is hematuria. It is erratic in its appearance, especially in the early period; and this uncertainty and apparent lack of reason may be descried as an earmark of tumor. Acting as a foreign body, a vesical tumor superinduces irritation and vascular changes that result in infection and cystitis, which adds its quota to the

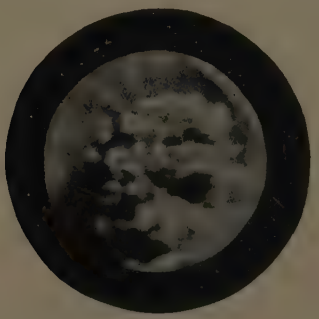


FIG. 181.—PEDUNCULATED VILLOUS PAPILLOMA, SIZE OF WALNUT (Nitze). Phosphatic incrustations on its surface.

FIG. 182.—UNEVEN, FISSURED SURFACE OF A BROAD-BASED CARCINOMA, DENSE TISSUE (Nitze).

symptomatology. Malignant tumors in their later stages place the stamp of their toxic influence on the patient, in the shape of debility and cachexia; and either constant misery or intermittent agony of the severest degree may fill the declining days and nights of such a sufferer. Some patients display the most extraordinary tenderness, crying out on the slightest manipulation, so that even the introduction of a soft catheter is insufferable without preliminary local anesthesia.

Diagnosis.—While the history and clinical manifestations may give evidence sufficient for a presumptive diagnosis of tumor, especially when confirmed by recto-abdominal palpation in some cases, they cannot fulfil the requirements for a comprehensive diagnosis as demanded at the present day. These can be furnished by the cystoscope alone. In addition to the actual presence of tumor, the investigator must be prepared to determine as accurately as possible the location, the appearance, and the number of tumors present, their mobility, mode of attachment to the wall, and the extent of involvement of the latter. All of these have a definite bearing on therapeutic deductions.

Two conditions sometimes render cystoscopy difficult, but seldom render it impossible: the excruciating tenderness of late carcinoma, and free hemorrhage from the tumor. If the local use of alypin (as described at page 287), together with a morphin suppository, does not suffice to deaden the sensibility, spinal anesthesia with alypin (½ or ¾ grain) or general anesthesia may be relied on for the purpose. There are three ways of meeting the other difficulty (active hemorrhage): administering stypticin (Merck's) in doses of 4 grains three times daily, internally; injecting a solution of one of the suprarenal extracts, 1 : 1000, into the bladder just before instrumentation; and the use of a cystoscope that affords abundant and rapid irrigation during the time of observation.

In case it be found impossible to make this means available (there are few conditions appertaining to the patient that can render it inexpedient), resort may be had to suprapubic cystotomy. In the absence of cystoscopic possibilities, either for diagnosis or for treatment, this, in all likelihood, will be the avenue of approach for operative measures or for permanent drainage, so there are no effective objections to it. Indeed, if hemorrhage be obstinate and severe, cystotomy is the logical measure and should be adopted without delay.

Prognosis.—While the trait of benignancy is attributed to all vesical tumors except carcinomata and sarcomata (Barling[9] and others), the irony of the term appears in the remark of Morton,[77] who says: "Benign tumors, if let alone, may cause death either from the repeated hemorrhages or from pyelonephritis following cystitis. They can be readily removed by operation, but are apt to grow again." It might be added that, while they are apt to grow again, there are many cases recorded in which permanent relief has followed the early removal of pedunculated tumors.

The prognosis of malignant tumor is much more gloomy than that of the benign type. It is not only more difficult of removal, requiring the coincident removal of parts of the bladder-structure, but its tendency to recur is even greater than that of the benign variety.

Treatment.—Although its results are not very encouraging, as indicated in the above remarks, there is no doubt of the advisability of removal of any pedunculated vesical growth, of whatever location or nature, and at the earliest possible moment. The natural tendency of such growths is to increase and to multiply; the earlier the removal, the easier the operation and the greater the likelihood of permanent relief.

With reference to the non-pedunculated or malignant growths, doubt is expressed in some quarters as to the justification of attempts at their removal, the argument being that they offer little promise of effectiveness, and when the tumors do return the conditions are not as favorable as they would have been without operation; and that life is not prolonged, but is sometimes shortened by operative measures. This same line of argument, it will be recognized, has been applied to malignant growths in other parts of the body, and it is probably no truer of this than of other parts of the body. *Early, radical extirpation* offers the greatest promise of permanent relief of any measure now attainable for vesical neoplasms.

Watson[116] has studied the records of 653 cases of vesical tumor (243 benign, 410 malignant), and has found that, following more or less radical operations, of papillomata and myomata, 34 per cent. were free from recurrence at the end of a year; of carcinomata, 28 per cent. were free at the end of a year. He sums up the results of operative treatment as follows: If the operative deaths and rapid recurrences are combined under the head of operative failures, such failures have occurred in 28.6 per cent. of benign tumors, and 46 per cent. of carcinomata.

In many instances removal of the tumor may be accomplished by snare and galvanocautery, through the operative cystoscope; in others suprapubic cystotomy and direct attack will be necessary. If the growth is pedunculated, an oval incision about its base, including the adjacent mucous membrane, with thorough excision, is the approved procedure, followed by cauterization of the site.

If the growth is sessile or involves the bladder-wall, the latter must be taken away with it, by freer incision through the entire thickness, with subsequent suturing of the edges of the wound.

Extirpation of the Bladder.—In view of the unsatisfactory results from excision or partial resection of the bladder for tumor, total extirpation of the bladder has been urged as a more effective means of eradication. Up to the present, there are records of twenty-five such operations for carcinomatous tumor, with eleven survivals and fourteen deaths, an operative mortality of 56 per cent.; survival, 54 per cent.

With this high operative mortality as a basis of his reasoning, Watson[116] proposes that, preliminary to the extirpation, double nephrostomy be done, *i. e.*, that permanent drainage of both kidneys be established, conducting the urine to the surface of the skin in the loins. This is to take care of the urinary secretion and remove it as a factor in the performance of the extirpation, and also to militate against subsequent renal and pelvic infection, the bête noir of rectal implantation, after the immediate dangers of the operation are over. Further, the suggestion of Watson permits the division of the operating into two stages, which is impossible in adopting either rectal (Maydl's plan[75]), vaginal (Pawlik's[88]), or urethral (Sonnenberg's[105]) implantation of the ureters. Nephrostomy is also proposed for inoperable cases in which the urine is the source of unrelenting misery in filling and emptying an intolerant bladder.

Extended discussion of vesical extirpation may be found in the excellent contributions of Hartley,[45] Mann,[73] and Bovée.[10,8,95,22]

The steps of the operation, as given by Rovsing,[98a] are described as follows: The bladder is filled with 200 c.c. of fluid and the patient placed in the Trendelenburg posture. Through a transverse curved incision, convexity downward, the bladder is exposed, its vertex and sides freed from peritoneum and other attachments, using ligatures as necessary. The posterior wall is carefully separated from the peritoneum if possible; if not, the peritoneum is freely incised and removed with the bladder. The ureters are secured by double ligatures placed one to two cm. from the bladder, and are severed by cautery. In women the remainder of the operation is done by blunt dissection, the neck of the bladder and about

two cm. of the urethra being freed and elevated. The urethra is clamped and severed with a small angiotribe. In the male more difficulty is encountered: The prostate and base of the bladder must be carefully separated from the rectum, which brings the membranous urethra within reach. It is clamped with a forceps and severed as before; only in this instance the forceps is allowed to remain for twenty-four hours, to prevent hemorrhage from the cavernous tissue. If the peritoneum has been opened it must be re-united by suture. The large wound-cavity is drained by the method of Mikulicz: A pocket of gauze is filled out with gauze strips, furnishing compression and absorption. The incised edges of the recti muscles are brought together with aluminum-bronze wire, followed by suture of the skin wound in the ordinary way. After this part of the operation, which lasts usually from one-half to three-quarters of an hour, a short lumbar incision is made on each side, extending from the edge of the erector spinæ eight or ten cm. outward. The ureter of each side is sought below its pelvis, is secured and carefully released from its attachments down to its severed end, and is brought to the surface. Both ureters then hang symmetrically for their whole length, in the triangle of Petit, eight cm. from the median line. The lumbar incisions are closed. The ureters are not attached, but are allowed to hang free, discharging into an appropriate receptacle, after a No. 12 catheter has been passed into each as far as their junction with the abdominal wall. They are protected by a perforated rubber finger-cot, drawn over them. These free ends shortly shrink and necrose up to within two to three cm. of the skin surface, where they may be cut off, leaving a beak-shaped projection that soon becomes covered with epithelium. The catheter is not re-introduced, the drainage being secured and cared for by means of a girdle and cup-shaped receptacles of silver that are connected by tubing to a rubber bag attached to the thigh. This apparatus must be worn both day and night.

Röntgen-ray Treatment.—While not enough experience has yet been had to determine the position of this treatment on vesical tumors, it may be mentioned that Gray[40] reports marked improvement from its use in a case of carcinoma in a gentleman sixty-seven years of age. The applications were made through a suprapubic opening, following surgical removal of the tumor from the base of the pedicle. After closure of the wound the patient remained well to the time of the report (eight months).

HERNIA OF THE BLADDER.

This is a condition long thought to be of infrequent occurrence, but now known to occur in about 1 per cent. of inguinal hernias. It is a protrusion of a part of the bladder wall from the abdominal cavity at some point in the lower abdominal wall, usually the inguinal canal, males largely predominating. The bladder may be within the sac of a large inguinal hernia, but this form is seldom encountered. In the commoner form the bladder is not within the hernial sac, but is at the side of the sac, the peritoneum covering the posterior and lateral wall of the bladder forming the inner wall of the hernial sac. In very rare cases the bladder alone and without any peritoneum forms the hernia.

Thinned, dilated bladders are for the most part met with in vesical hernia, and individuals the subject of urinary obstruction or of lowered state of health are most liable to the condition.

The chief importance of vesical hernia consists in its liability to inadvertent injury during the performance of herniotomy. The seriousness of this accident appears in the figures collected by Lotheissen,[69] of sixty-five such cases, with eighteen deaths.

Diagnosis.—In the physical examination of hernia containing a part of the wall of the bladder it may be noticed that desire to urinate is aroused by the manipulations of the examination; the patient may mention that his urination is accomplished in several stages, instead of all at once; that the hernia gradually increases in size with the filling of the bladder, etc. Any suspicion of the presence of hernia of the bladder in connection with an existing tumor of this kind should be tested by the use of the cystoscope, in which the retrospective lens is employed, in order to detect a protrusion in the direction of the operator. Manipulation of the sac externally while observation is being made through the cystoscope may furnish valuable evidence in establishing the connection.

Treatment.—As with other hernias, a well-fitting truss may give good service for palliation; but complete restoration may only be expected from a radical operation. The accidental incision of the bladder should be at once followed by tight closure with two rows of chromicized catgut sutures before reducing the protrusion; testing with intravesical injection of boric solution; the retention of a soft catheter in the bladder, per urethram; and the completion of the radical procedure. Such a course relieves the accident of most of its danger.

FOREIGN BODIES IN THE BLADDER.

Foreign bodies reach the cavity of the bladder by intentional or by accidental means. The variety of objects embraced in the list is surprisingly large. In addition to calculi, pieces of suture, of broken catheters or bougies, bony sequestra,* and other substances with more or less legitimate excuse for their presence, there are parts of pencil, straws, glass tubing, beads, wax, chewing-gum, hair-pins—in fact, every conceivable object that may be made to enter the urethra for the purpose of titillating the feelings and the erotic fancies of masturbators. The hair-pin is a favorite object with the female. These various means are used, perhaps, repeatedly, until finally, under the influence of sexual excitement or orgasm, they escape the grasp and are forced into the urethra, when they are pressed into the bladder by the excited efforts at regaining them by the patient.

In other instances soft catheters are left *à demeure*, but escape from the retention apparatus and find their way into the bladder. A husband lost a catheter in the urethra and bladder of his wife while endeavoring

* Haggard[42] found the full skeleton of an ectopic fetus that had ulcerated its way into the bladder of a patient. Dunn[26] found a bony sequestrum nearly an inch long.

to pass it into the uterus for the purpose of causing abortion; and in a patient of my own a veterinary surgeon used a willow switch instead of a bougie for enlarging the caliber of a supposed deep urethral stricture; about three inches of the switch broke off within the bladder, formed the nucleus for phosphatic incrustations, and developed into a stone of large size, requiring removal by suprapubic cystotomy a year later.

This is a frequent outcome of such an accident: The patient, impressed with the shame of his act, fails to ask assistance until months later; the foreign body evokes irritation, infection, and cystitis, and he finds further delay impossible.

Treatment.—It was formerly necessary to cut down for the removal of all such foreign bodies; but ingeniously contrived hooks, alligator forceps, and lithotrites, besides the operative cystoscope and its accessories of modern devising, have materially lessened the occasions for such radical measures. Of two hundred and forty-nine cases collected by Denuce there were, prior to 1830, twenty-seven extractions and one hundred cystotomies; between 1830 and 1856, twenty-two cystotomies and one hundred and one cases of extraction; with a similar increase since that time.[36]

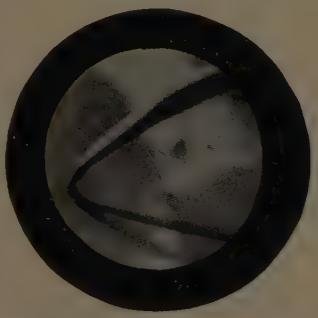


FIG. 183.—SHOWING HAIR-PIN IN THE BLADDER OF A YOUNG WOMAN (Nitze).

The shafts of the pin appear divergent, but are really parallel.

Practically all small objects, such as portions of catheters, sticks, hair-pin, stone, bone, etc., may be removed by means of the operative cystoscope and appropriate accessory instruments (see p. 291). Even friable wax or gum may be thus removed with a scoop. After phosphatic incrustation of such an object has progressed far, crushing may be necessary, or removal by incision through the perineum or the suprapubic area. Keyes[51] calls attention to the especial danger from pieces of glass in the bladder and their liability to cut or injure the bladder incidental to efforts at extraction; and advises that immediate cystotomy be performed in such a case.

INJURIES OF THE BLADDER.

Because of its situation deep in the well-padded bony pelvis, injuries to the bladder are rare compared with those of the more exposed organs of the body; and it requires an extreme degree of violence to reach or affect it. Nevertheless, a force that is powerful enough to injure the bony pelvis does not usually fail to leave its impress on the bladder as a contusion, a wound, or a rupture.

Contusion.—Theoretically possible, but practically rare, this injury is sustained from a kick or a fall in which there is bruising of the bladder without solution of its continuity. It may occasion derangement

of the vascularity of the organ to such a degree that fairly active hemorrhage results, with the formation of clots in the organ. Some degree of temporary shock to the patient is usually observed.

The chief point of importance connected with this injury is its differential diagnosis from rupture of the bladder, a mistake which leads to delay, and delay in proper treatment, even for a moderate number of hours, may result in the loss of the life of the patient. This subject will be considered further under Diagnosis of Rupture of the Bladder.

WOUND AND RUPTURE OF THE BLADDER.

Definition.—The term "wound of the bladder" indicates a break not only in the continuity of the bladder itself, but also of the skin and soft parts surrounding it. Rupture indicates a solution of continuity of the bladder, without wound-communication with the external surface. Practically, the essential difference between the two conditions is the morbid communication with the external surface; hence, with this distinction understood, they may properly be discussed together.

Sources and Mode of Injury.—These injuries may result from either direct or indirect violence; and may be either intraperitoneal or extraperitoneal, that is, the break in the bladder-wall may or may not involve the peritoneal covering, depending on the location and extent of the injury.

The *full bladder* is the vulnerable bladder, the one most liable to injury from any form of violence. Large and tense, it is exposed to stab wounds and gunshot wounds in broils; to puncture or laceration from a fall in which the abdomen is pierced by a picket or stake, or the object of an attack by a horned animal; or to penetration by bony spiculæ in case of fracture of the pelvic bones. It is also more vulnerable with respect to rupture, from any of the many ways in which that injury is sustained: from kicks, blows, falls from a height; the passing of vehicle wheels over the abdomen; from spontaneous rupture in connection with straining efforts incident to parturition, obstructed urination or difficult stool (in the presence of pathologic bladder). Crushing injuries that roll the patient between two cars may cause rupture, wound, or laceration of the bladder.

While injury from all of these effects is more likely to happen to a filled bladder, it must be conceded that the empty state does not secure immunity from direct force. A stake or fence picket that penetrates the perineum in a fall also may penetrate the bladder, whether full or empty.

Injury to the bladder may be produced by means of surgical instruments, lithotrites, forceps, or metal catheters. Neumann, in extracting an adherent stone in a boy, tore through both bladder and rectum.[118]

Prognosis.—The vast difference between the results of such injuries under the older "expectant" plan of treatment and the modern one is indicated by reference to the statistics on the subject. Bartels[4] in 1882 analyzed one hundred and sixty-six cases of rupture of the bladder, which gave one hundred and forty-nine deaths and seventeen recoveries, a

mortality of 90 per cent. In 1903 D. F. Jones[49] analyzed fifty-four cases of later occurrence, finding twenty-six deaths, and twenty-eight recoveries; mortality, 48 per cent. Of the twenty-two cases published since 1892, quoted by Horwitz,[48] there have been seven deaths and fifteen recoveries; mortality, 27.5 per cent. This great improvement has been brought about by prompt operation.

Symptoms and Diagnosis.—The two questions most urgent of solution in all of these injuries are: (1) Is the bladder itself involved, either by wound or rupture? (2) Is the injury intraperitoneal or extraperitoneal? On the prompt and correct determination of these two questions, backed up by the immediate application of appropriate surgical measures, more than upon anything else depends the death or the salvation of the patient. This, however, is not always easy of accomplishment, even where there is a wound of the external structures, for the urine, in such a case, may not appear externally, but may leak into the tissues or into the peritoneal cavity, failing to afford the clue that it might otherwise furnish.

Following the receipt of injury that ruptures the bladder or that causes a wound without external drainage of urine, there is usually *shock* of pronounced proportions. There is also complaint of severe pain in the lower part of the abdomen, frequent but futile efforts are made at urination; and when the catheter is passed, only a small quantity of urine is found in the bladder, and this is tinged with blood.* When fluid is injected there is no return through the catheter of the same amount as was injected. Further, instead of the injection being followed by the usual globular tumor of a filled bladder in the pubic region, dull on percussion, none of the signs of the bladder are perceptible; but there is increasing dullness in the flanks, as in ascites.

The next striking change is the onset of peritonitis and its train of symptoms, thready pulse, hiccough, and vomiting. Peritoneal infection is not necessarily an immediate follower of the entrance of urine into the peritoneal cavity, as many cases of rupture are reported in which patients continued to be about, or even at work, for days after the injury, their abdomens containing urine all of the intervening time; and not until catheterization had been applied had the infection taken place.

If the urinary leakage is into tissues outside of the peritoneum, there is steady accumulation and diffusion of urine here; which, when it becomes infected, develops phlegmon, abscess, sepsis, possibly peritonitis if appropriately located; and unless prompt and effective surgical action be taken, the outlook becomes as serious as with intraperitoneal leakage.

In no crisis of surgery are the forceful mind and master hand needed more than in this one. "Masterly inactivity" leads to sure death; deferred activity, to the same conclusion. Of the cases of rupture operated on within the first twelve hours, the mortality is about 38 per cent.;

* This, however, does not always follow, as Herrick[46] reports two cases in which large rents in the posterior wall of the bladder permitted the entrance of the catheter into the abdominal cavity and the withdrawal of large quantities (one quart in one case, a pint and a half in another) of bloody urine, in a forceful stream.

from twelve to twenty-four hours, 70 per cent.; after this, about 73 per cent. The necessity for prompt action is, therefore, apparent.

The symptoms and signs mentioned make a strong chain of evidence presumptive of ruptured bladder, under which circumstances definite steps should be taken to determine the question. Hydrogen or oxygen gas has been recommended for injection through a sterile catheter, and its behavior observed; or sterile water has been used for the same purpose. But these means have not received the undivided support of writers. Together with the cystoscope, they are condemned by Horwitz,[48] who says: "It is evident that there is no known means that can be regarded as a reliable aid in attempting to diagnose rupture of the bladder. All the expedients suggested are fraught with more or less danger to the patient; the use of the sterilized catheter is probably less dangerous than any of the others. It follows, therefore, that in all cases of doubt, instead of losing valuable time . . . . it is wiser to proceed at once with an exploratory operation." It is conceded (White and Martin,[118] page 408) that cases simply of contusion of the abdomen and bladder may give rise to perfect simulation of rupture, embracing the typical symptoms of shock and bloody urine; and also that suppression of urine, with alcoholism, sometimes presents the same syndrome of symptomatology. With these facts in view, it is hardly justifiable to undertake laparotomy on a mere suspicion. Tangible evidence, other than that of fatal delay, is desired. It is probable that a well-equipped cystoscope is best adapted to furnish this evidence, and with the least harmful effect.

While it is a question whether the older forms of one-view, non-irrigating cystoscopes could be employed to advantage, a model supplied with ample irrigating facility and readily interchangeable lenses (direct, right-angle, and retrospective) is well calculated to determine the existence, size, and location of a vesical rupture, or a rent in the bladder communicating with an outside wound. Such a cystoscope supplies a view during the passing in of the fluid, at least; and even if the view be interrupted shortly, a glimpse may be sufficient for all diagnostic purposes. In case of a shot wound, the missile may have remained in the bladder, or may have passed out through a second wound, with or without peritoneal perforation, on which questions, also, the cystoscope may throw valuable light.

Treatment.—Fenwick states that rupture is intraperitoneal in 88 per cent. of cases; Ulmann[110] believes 85 per cent. With extraperitoneal injury the surgical requirements depend largely on the amount of leakage of urine into the tissues, together with its infectiousness. If these are pronounced, time should not be wasted, but the affected parts should be promptly reached by incision and free drainage should be established in addition to leaving a soft catheter in urethra and bladder. Other surgical principles applicable under such circumstances are to be followed.

If it is determined or strongly suspected that the injury involves the peritoneum, immediate preparations for laparotomy should be made. A median incision, moderately low down, permits observation of the abdominal contents (as to blood, urine, etc.) and also allows a direct

examination of the bladder for a tear or perforation. On locating one, its edges are trimmed, cleaned, and closed with Lembert sutures, reinforced with a second row of sutures if there is reason to doubt the efficiency of the first; after which the toilet of the peritoneum is made and drainage is provided. A rubber catheter is retained in the urethra and bladder for a week. If the bladder has been opened incidental to the operation, direct drainage from it may also be arranged for, possibly leaving the abdominal wound partially open and the intestines walled off with gauze.

It is at times difficult to place sutures in a deep-lying wound of the bladder, say, in the bas fond; in which case assistance is gained by placing sutures in the anterior end of the wound first and using them for traction.

VESICAL FISTULA.

A fistulous tract may connect the bladder with the outer surface of the skin or with some neighboring organ; and such connection determines its designation, as vesicorectal, vesico-intestinal, vesicoperineal, vesico-abdominal, etc. Vesicovaginal and vesico-urethrorectal fistulas, together with those from patent urachus, are discussed elsewhere.

The causes of vesical fistulas are numerous. They embrace those arising from surgical operations, both intentional, for prolonged drainage of the bladder, and unintentional, the result of complicating conditions in connection with operations; they include those of traumatic, tuberculous, and malignant origin; and those from ulceration or abscess-formation, the sequence of calculus in the bladder or concretion in the bowel.

Of ninety-five cases of vesico-intestinal fistulas analyzed by Chavannaz,[15] thirteen were traumatic, twenty-nine ulcerative (from stone, abscess, etc.), nineteen malignant, seven tuberculous, and twenty-seven unclassified.

Symptoms.—The most constant symptom of vesical fistula is the escape of the urine in an abnormal direction. Next, the appearance in the bladder and urine of materials or products of other organs (feces, gas, undigested particles of food). Pneumaturia is caused most frequently by fistulous connection with the bowel, but it also arises from bacterial activity or fermentation in the bladder; so this is not pathognomonic of intestinal communication, as some authors claim. If the fistula connects with the small intestine or the proximal end of the colon, although urine may enter the bowel it does not necessarily become evident in the feces, as it thoroughly mixes with the latter, under such circumstances. Cystitis is, of course, to be expected, from the presence of infective foreign materials.

Diagnosis.—Vesical fistula is to be differentiated from that of urethral origin by observation at the time of urination. If the connection is with the bladder, the leakage is liable to be continuous; if from the urethra, leakage occurs only at the time of urination.

Tests may be made by injecting indigo-carmin or methylene-blue solution into the bladder and watching for its escape at suspected points. Or hydrogen peroxid may be injected into the fistulous tract and lead to

the appearance of bubbles and air in the bladder, made evident at the first subsequent urination, or by coincident observation through a cystoscope. The latter is preferable, as it indicates the locality and size of the abnormal opening in the bladder.

Treatment.—Palliative or operative measures may be adopted, according to individual indications.

One primary and fundamental condition must be fulfilled before success can be expected: All resistance or obstruction to the escape of urine in a direction other than through the fistula must be removed. However diligent the operator may be in treating a fistulous tract, if he neglect to remove obstruction from a urethral stricture, for instance, he invites inevitable defeat at the outset. After providing for this (by operation or the retained catheter), he may turn his attention to the treatment of the fistula itself. This consists in freshening or curetting the tract with a sharp gimlet-curet, followed by swabbing with pure carbolic acid or nitrate of silver fused on the end of a probe by heat. To this may be added a deeply placed suture of silkworm-gut to maintain close apposition of the freshened walls; with a retained catheter to serve for continuous drainage for a week. If there is much cicatricial tissue surrounding the tract, it should be cut away previous to closure.

Vesico-intestinal fistula (non-malignant and non-tuberculous) is to be treated by laparotomy, severance of the gut from the bladder, freshening and suturing of both fistulous openings, followed by provision for ample and continuous drainage and frequent irrigation of both organs. Temporary colostomy may be added for greater certainty of the result.

Fistulas of malignant or tuberculous origin are practically incurable, and palliative treatment alone is applicable to them. This consists chiefly in irrigation and drainage. If the fistula involves the intestine, permanent colostomy may be demanded, where there is excessive suffering from the entrance of fecal masses into the bladder; or Watson's suggestion of nephrostomy[116] may be indicated for relieving the cancerous bladder of all contact with irritating urine.

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CHAPTER LVIII.

STONE IN THE BLADDER.

By Arthur Tracy Cabot, M.D.,
BOSTON.

A stone in the bladder is a concretion which the bladder is unable to expel *per urethram* and which therefore requires surgical interference for its removal.

Physical and Chemical Characteristics.—These concretions may be classified according to the principal calcareous ingredient which enters into their composition, and may be divided into the following groups:

1. Uric acid stones, composed of uric acid and the acid urates.
2. Oxalic acid stones, composed of oxalate of lime.
3. Phosphatic stones, which contain alkaline phosphates and carbonates, not infrequently combined with urate of ammonia.

Certain other organic substances which are found in the urine sometimes exist in sufficient amounts to form calculi. Cystin is the most common of these. Xanthin and indican calculi have been reported. Masses of cholesterin and fibrin have been observed. Hematoidin and urinary coloring-matters are also found in stones; usually in inconspicuous quantities. These rare constituents of urinary calculi have interest in connection with biologic chemistry, but are so infrequent as to have little practical importance.

While most calculi fall naturally into one of the three classes named above, it is not unusual to find one belonging partly in one group and partly in another. Thus a stone with a uric-acid nucleus may have a layer of oxalate of lime around it, and again outside of this a phosphatic layer.

If the calcareous parts are dissolved out of a stone, an albuminous mass is left which preserves the shape of the stone. This basic substance exists in all calculi and serves as a framework in which the salts are deposited. Cystin stones have less of this albuminoid basis than the other urinary calculi.

The investigations of Rainey, Harting, Ord, Ebstein and others have shown the importance of this mucoid skeleton or albuminous matrix in which the stone is deposited. These observers have shown that when colloid or albuminoid substances are added to solutions of crystalline salts a change takes place in the crystallization of these salts. They develop in such media a tendency to deposit in spheroidal shapes and to coalesce in rounded forms. This tendency was called by Rainey the law of "molecular coalescence," and the importance of it in controlling the formation of urinary concretions is obvious.

The albuminoid material necessary for stone formation may be supplied by pus, blood, or by bits of necrotic tissue. As these materials are supplied by the walls of the urinary passages, it would seem that some irritation of these passages must precede the formation of a calculus.

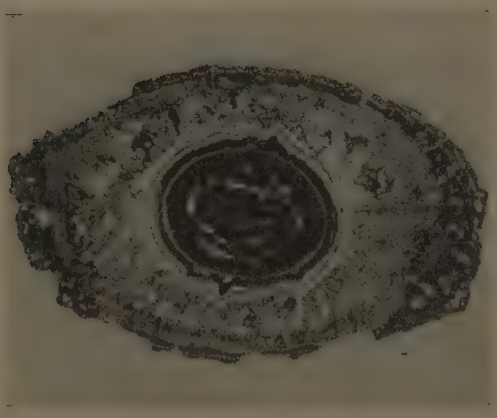

FIG. 184.—SECTION OF STONE HAVING A NUCLEUS OF URATE OF SODA, A MIDDLE LAYER OF OXALATE OF LIME, AND AN OUTSIDE LAYER OF EARTHY PHOSPHATES (after Ultzmann).

If granulation tissue forms in the bladder, its surface secreting albuminous material is a favorable nidus for the deposit of calcareous salts. The surface of a tumor acts often in a similar way to set in operation the formation of a stone.

The concretion when started acts as an irritant to the bladder wall and so continues to be supplied with an albuminoid envelope in which successive layers of spheroidal crystals are deposited. On a cross-section of a stone may be seen the concentric layers of which it is composed. The compactness of the different layers also varies considerably even when the constituents are tolerably uniform.

Inspection of such a section will show also an indistinct striation radiating from the center out through the concentric rings. This arrangement makes distinct lines of cleavage, which we shall find of some practical importance when we discuss the subject of spontaneous fracture of stone.

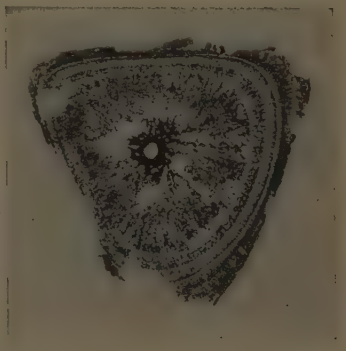

FIG. 185.—A STONE COMPOSED OF EARTHY PHOSPHATES.

In the central portion it shows the radiating striæ, surrounded by outer concentric layers (Ultzmann).

Color.—Stones vary in color according to their constitution. Uric acid and the urates are yellow or yellowish-red. Oxalate of lime is brown or gray in color, often so dark as to be practically black. Phosphates and carbonates are white, shading off into gray.

Consistence.—Urinary stones vary greatly in their degree of hardness. Oxalate of lime stones are very hard, requiring great force to crush them. Stones made up of urates are somewhat less hard; then come stones containing carbonates and phosphates, and among the softest stones are those consisting of pure uric acid.

In some stones the deposit of earthy salts is very scanty and the calculus is little more than a soft mass of mortar. Rarely we see concre-

tions in which the earthy portions are almost wholly absent and the successive layers are made up of tough, coagulated albuminous material. These albuminoid masses are sometimes of considerable size, reaching a diameter of two inches or more. Soft layers interposed between harder layers greatly weaken the resistance of the stone to crushing instruments.

Shape.—The shape of a stone is determined first by the more or less even deposition of the calcareous salts upon it; secondly, by the friction of the bladder walls; thirdly, by the friction of other stones; lastly, by the molding of closely surrounding walls, as when the stone or a portion of it lies in the ureter or urethra or in a pocket in the bladder. This molding is accomplished by an interference with the deposition of salts on the sides of the stone that are closely hugged by the containing walls, so that the growth takes place most rapidly on the free surfaces. Also, the walls by closely grasping the stone may wear away the surface after it has been formed. Occasionally a stone is made up of an agglomeration of several stones, which cohere. Great irregularity of shape may arise from this arrangement.

The surface of a stone varies according to the constitution of its outermost layer. Uric acid or the urates give a tolerably smooth surface; a phosphatic stone is somewhat rougher and an oxalate of lime stone has a very irregular, often prickly or knobby surface (mulberry calculus).

Multiple Stones.—Stones usually exist singly in the bladder, but it is not an infrequent occurrence to find more than one; and sometimes several hundreds are found in one bladder. When many exist they are usually small, with rounded outlines. As they become larger and rub against each other more evenly and firmly, they wear off surfaces and become facetted. This is especially the case when they are confined in a pocket where they are held in close apposition.

The Spontaneous Fracture of Stones.—That stones sometimes break spontaneously in the bladder had long been known, but Ord was the first to furnish an adequate explanation of it. Rainey found that spheres of carbonate of lime which had been formed in a solution of gum would split up radially and disintegrate if they were immersed in solutions of a different specific gravity. Ord held that the splitting up of a urinary calculus was, in a similar way, due to the action of urine of a different specific gravity and reaction from that in which the calculus formed. He supposed that the colloid material in the stone swelled by imbibition of urine of a different density, and that the nucleus, becoming thus enlarged, broke the outer enveloping layers by an "explosive disruption such as would occur in a thick-walled shell." In three of Ord's cases the fragments, which were of uric acid, were covered with urate of ammonia, from which fact he argued that the urine had become alkaline, and that to this change was partly due its action on the colloids of the stone.

Englisch* has pointed out that the rifts and ridges which start from the deep layers and run to the periphery make for spontaneous fracture. When the radiating rifts are highly developed and reach the surface of

*Englisch: Arch. f. klin. Chir., lxxvi, 961, 1905.

the stone, they come in contact with the urine in the bladder. This can then bring about solution of the substances in the clefts, and reaching the deeper layers and providing increase of volume in them or by gas formation may produce a breaking up of the stone.

This explanation differs little from that given by Ord many years ago.

It seems probable that some of the reported cases of solution of stone in the bladder by the drinking of lithia or other spring-waters are instances of spontaneous fracture due to a great thinning of the urine by the excessive water-drinking.

Etiology.—In considering the circumstances that lead to stone formation we have two sets of causes to investigate.

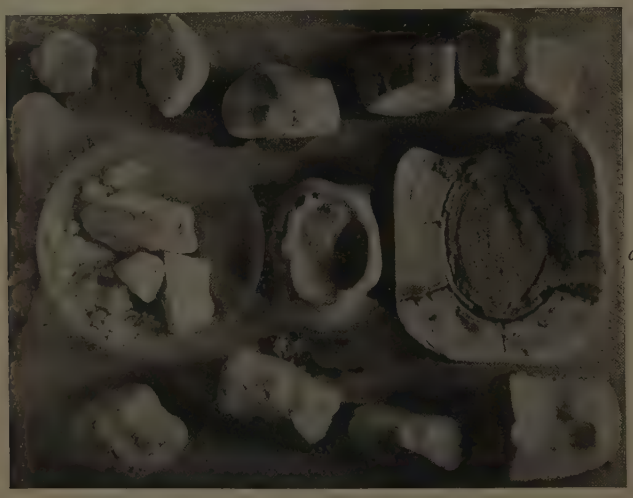

FIG. 186.—SPONTANEOUS FRACTURE OF STONE.

Photograph of a specimen in the Norwich and Norfolk Hospital (obtained through the kindness of Mr. Ballance). The specimens were from a post-mortem in a case not operated on. The section of a stone (*a*) shows the urate nucleus with thick shell of carbonates and phosphates about it. This outer shell has begun to split radially, showing the method of spontaneous fracture. The other fragments are the results of an old spontaneous fracture. Their rounded edges show that they have lain long in the bladder since breaking apart. Probably they formed originally on the urate nucleus; then after they broke off from it, the shell reformed and this second shell is now splitting off.

First, the general conditions and tendencies, diathetic and otherwise, that induce the overproduction in the system of the materials which are deposited from the urine in the shape of calculi; and, secondly, certain local conditions which favor the deposition of these solids out of the urine.

Locality.—That the distribution of stone is irregular, it being much more abundant in some countries and localities than in others, has been variously explained. It is probably due to the habits of the people, in ways of living, and selection of food and drink, rather than to telluric or atmospheric influences.

Heredity.—That heredity may have an influence in determining a predisposition to stone is undoubtedly true, and many instances are reported in which the uric-acid diathesis has existed through several

generations in a family, and has made its members liable to the occurrence of calculous disease. Whether a tendency to oxaluria or phosphaturia is similarly transmissible is not so clear. The influence of heredity has been evoked as one factor leading to the frequency of stone in certain neighborhoods, where generations of intermarriage might fix calculous tendencies on the people.

Diet and Habit.—The influence of diet and of habits of life upon the excretion of uric acid and oxalate of lime is unquestioned. Thus, the customs of a people, their ways of living, and their choice of food, may have a decided influence on the frequency of stone among them. Uric acid and oxalate of lime are often found abundantly in the urine of poorly nourished children, in whom the processes of digestion and of oxidation of tissues are imperfectly accomplished; also in older individuals who take large quantities of nitrogenous food, and whose functions are sluggishly performed. It is therefore in these two classes that acid stones most commonly form. Thompson has pointed out the fact that stone is common among the children of the poor, while among the rich it spares the children and appears among the old men. This observation refers only to primary calculi; for secondary calculi, due to fermentation of the urine, are more common among the aged poor, who pay but little regard to a moderate cystitis. In the case of oxalate of lime, its appearance in the urine may come about in a way even more direct; for the ingestion of certain articles of food that contain vegetable acids abundantly often leads at once to the deposition of large amounts of oxalate of lime in the urine. Chismore has found oxalate-of-lime stones disproportionately abundant on the Pacific coast of North America, and is inclined to ascribe this to the fruit-eating habits of the people.

Diathesis.—The association of stone with gout and rheumatism is so well recognized as only to require mention.

In some diseases of the liver and spleen an excess of uric acid is observed and the formation of a stone under these circumstances has been recorded.

When we consider phosphatic stones we find that while such a stone may occasionally result from the phosphatic diathesis, it is far more common to see a stone of this kind as the result of a local process.

Alkaline Fermentation.—In chronic cystitis, sooner or later the urine becomes alkaline and throws down crystals of triple phosphates and other alkaline salts. The condition that especially favors alkaline fermentation is partial retention (residual urine). This is usually the result of some obstruction by enlarged prostate or stricture. Rarely atony of the bladder leads to the same condition. An obstruction favors stone formation not only by causing alkaline fermentation but also by retaining crystals or small concretions which a healthy bladder would be able to expel.

Symptomatology.—If a stone in the bladder forms upon a renal stone which has found its way down through the ureter, we have a history of renal colic, followed later by a gradually increasing vesical irritation. A stone which forms primarily in the bladder may reach a considerable

size before it gives rise to symptoms which call attention to its presence. On the other hand, a very small stone may cause so much irritation as to give rise to aggravated symptoms.

It is rare to see a case of stone exhibiting all of the characteristic symptoms. Some of them are usually quite pronounced, while others may be absent or but slightly noticed.

Increased frequency of urination is present in all inflammatory conditions of the bladder and is early noticed in cases of stone. The frequent micturition due to stone is usually marked, and sometimes so extreme that the patient urinates every few minutes. When a considerable degree of tenesmus exists, there may be almost constant spasm of the bladder, accompanied at times by spasm of the rectum and even by prolapse of the bowel.

The frequency caused by a stone is increased by motion and is usually diminished at night during recumbency. This is the reverse of what is true in the frequency caused by enlarged prostate, which is often greatest at night, and especially in the latter part of the night.

Sudden Stoppage of the Urine.—When the stone is drawn, by the outflowing stream of urine, against the internal orifice of the urethra, it causes a sudden stoppage of the flow with a sharp pain. This symptom occurs more commonly in the undistorted bladder of youth and middle age. When in old age enlargement of the prostate has raised the urethral orifice and formed a post-prostatic pouch, the stone does not so readily fall against the urethra.

Pain caused by stone in the bladder varies greatly in intensity, but has special characteristics which make it the most valuable symptom we have for diagnosis. It may appear as a general sense of weight and discomfort above the pubes, in the perineum, or in the rectum. When more severe, it may be felt as a cutting or pricking. These pains show a tendency to shoot out along the urethra. Usually a considerable part of the pain felt is referred to the end of the penis. In children a lengthened prepuce often results from constant pulling at it in the effort to relieve this penile pain. Occasionally a patient refers the pain wholly to the rectum and has a sensation as if a paper of pins were in the lower bowel. The pain, wherever felt, is usually increased at the end of urination. This is due to the irritation of the stone as the bladder closes down upon it. This increase of pain after urination may be absent in a bladder that does not completely empty itself.

The notable and characteristic thing about the pain of vesical calculus is its aggravation by motion. Jolting in a wagon is very trying to these patients and twinges of pain may be produced if the patient rises on his toes and then comes down hard on his heels. Even quiet walking causes at times great suffering, and some patients cannot turn in bed without an added twinge.

Reflex Pains.—Besides the pain caused directly by the contact of the stone with the sensitive bladder, we sometimes find reflex pains in distant parts. These pains are referred to the hips, to the thighs, and even to the lower leg and foot, also occasionally to the shoulders and arms.

The condition of the urine varies greatly in cases of stone. If the stone has not caused much bladder irritation, the urine may be nearly clear to the eye. Even in these cases, however, the microscope will show the presence of small quantities of pus and blood, with crystals of uric acid or oxalate of lime.

As the bladder irritation increases, the urine becomes more and more cloudy, and if the amount of blood is appreciable, it may assume a smoky appearance. If the urine becomes alkaline, the pus takes on a gelatinous, ropy condition, often stained with blood.

Hematuria.—As has been said, a small amount of blood is always to be found in the sediment. Not infrequently it appears in sufficient amount to highly color the urine or even to lead to the formation of considerable clots in the bladder. The appearance of blood or its increase in the urine after prolonged motion and its relative disappearance during rest is a characteristic accompaniment of stone.

Occasionally the blood appears mainly at the end of urination, a few drops being squeezed out as the bladder closes down on the rough stone. In a patient with the hemorrhagic diathesis or in cases of greatly congested prostate the bleeding caused by a stone may reach serious proportions.

Diagnosis.—Various conditions of the urinary organs may produce symptoms closely resembling those of stone in the bladder. Inflammatory conditions, tuberculosis, and new-growths of the bladder and prostate, and stone or tuberculosis of the kidney, may be difficult or impossible to differentiate by the symptoms alone. Stricture or chronic inflammation of the urethra and neuralgia of the neck of the bladder may cause symptoms at times misleading.

As has been said above, the distinct aggravation of pain on motion is often very characteristic in cases of stone. When an increase of blood in the urine also appears after exercise, the evidence in favor of stone becomes very strong.

The only sure means of settling the diagnosis is by physical examination. This examination may be conducted in a variety of ways.

1. Digital exploration through the rectum or vagina.
2. Exploration with searcher or sound, including examination with a lithotrite.
3. Exploration with a litholapaxy pump.
4. Examination with a cystoscope.
5. Digital exploration through the dilated urethra in woman, or through a median perineal opening (boutonnière) in man.
6. Digital and ocular examination through a suprapubic opening.

1. By the usual bimanual rectal or vaginal examination a stone may be felt not infrequently, and its approximate size may be made out. This examination is easy and especially valuable in children. During the search with instruments in the bladder the finger in the rectum may be of service by lifting a stone in a post-prostatic pouch up to the sound. In case of a sacculated stone the finger may aid the sound in locating the stone.

2. Exploration with a searcher is familiarly known as "sounding for

stone." A metallic instrument is used, and the contact with the stone is perceived by the sense of touch. The sensations conveyed through the instrument to the hand are of two sorts, either a sharp shock of impact or a scratching sensation produced as the instrument slips over the surface of the stone.

The searcher should have a shape to permit of its ready introduction and easy manipulation within the bladder. A hard metal gives a more distinct sense of contact than a soft one. The accompanying illustration (Fig. 187) shows the form of searcher usually preferred. The shaft is thin (No. 12 to 15 French scale) so that it may lie loosely in the urethra, and be easily moved to and fro or rotated. The beak is somewhat larger with rounded, blunt end so that it may slide easily through the urethra and over the walls of the bladder, is rather short and set at an angle of about 120 degrees with the staff. An instrument of this form can be easily rotated in the bladder and will sweep around close to the neck of the bladder and so reach a stone close behind the prostate.

The Operation of Sounding.—Whether anesthesia shall be used for sounding must be decided in each case for itself. In children, general anesthesia is almost essential. In adults, sounding may usually be accomplished satisfactorily without general anesthesia. In sensitive cases a

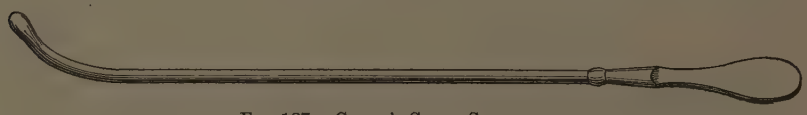

FIG. 187.—CABOT'S STEEL SEARCHER.

5 per cent. solution of cocain injected into the urethra and bladder and held there for ten minutes will render the subsequent manipulations practically painless.

When the deep urethra is rigid from enlargement of the prostate or from any other cause, and when the bladder is contracted and spasmodic, general anesthesia is essential to a thorough and satisfactory sounding. In such a case preparation for the removal of the stone should be made, so that the shock and inconvenience of two sittings of anesthesia and instrumentation may be avoided.

Sounding should be conducted with the patient in a horizontal position. The bladder should be moderately distended with water so as to permit of the easy manipulation of instruments within it, and to preclude the possibility of the stone being concealed within its folds when collapsed.

The searcher is similar in shape to the lithotrite, and the proper method of introducing an instrument of this form will be described in the consideration of lithotrity.

When it reaches the bladder the instrument should be carried to the most dependent part. If the stone is not at once touched, the beak should be rotated from side to side and then withdrawn a little, and again rotated, and so on until the face of the prostate is reached. In this way the whole floor of the bladder, where the stone usually rests, will be searched.

If the prostate is enlarged, the handle should be then depressed and the beak rotated through the post-prostatic pouch, where a stone often lurks. The lateral walls should then be searched. They may be reached by carrying the handle first toward one leg and then toward the other. The upper wall of the bladder may be reached by depressing the handle well between the thighs. This maneuver will also bring the beak in contact with a stone lying on top of an enlarged third lobe of the prostate.

Finally, if the stone has not been found and if the operator is using a hollow searcher, the bladder may be slowly emptied, so that as it shuts down the stone may be brought against the instrument. Keyes advises that this be done with the patient standing upright or leaning slightly forward. As the water runs out, the beak of the searcher should be kept close to the prostate and rotated gently from side to side. He says that a stone rarely eludes this examination.

Sources of Error in Sounding.—(*a*) The searcher may not enter the bladder. It sometimes happens in cases of enlarged prostate that the sound has been arrested in the prostatic urethra and has such a degree of mobility that it is thought to be in a contracted bladder. This mistake is unlikely to occur in an examination under ether.

(*b*) A small, light stone may give too little shock of contact to be perceived by the sound.

(*c*) A stone may be so enveloped in mucus or blood that the sound cannot be brought in contact with it.

(*d*) An encapsulated stone may be out of reach of the searcher.

(*e*) Sometimes the mistake is made of thinking that a stone is felt where none exists. A tumor incrusted with lime salts may be mistaken for a stone. This may be suspected if the stone is always felt in a part of the bladder where it would not be kept by gravity. A stone partly projecting from a pocket and a stone formed upon an ulcerated surface, and so adherent to the bladder wall, would give the same sensation, so that a diagnosis between these conditions may be impossible with the searcher. When a hollow searcher is used, the rush of water into it when it reaches the bladder may give a shock so exactly like a stone as to deceive the most practised touch.

Some of the above sources of error may be avoided by using a lithotrite for sounding. A stone too light and small to be felt with the searcher, or one enveloped in mucus, may be perceived when grasped in the jaws of the lithotrite. In sounding with this instrument it is sometimes possible to tell whether more than one stone exists, for with one stone held firmly in its jaws the lithotrite may be used for further search.

When a stone is touched, it may be possible to tell whether its surface is rough or smooth, and something may be learned of its consistence by sharpness of the ring which the instrument makes against it.

The attempt is sometimes made to judge of the size of a stone by the searcher. This is done by carrying the beak to the further end of the stone and then gradually withdrawing the instrument along the side of the stone, tapping gently against it, until the nearer end is reached. A

much more accurate way, of course, is by seizing the stone with the lithotrite.

Sounding boards and stethoscope tubes connected with the searcher to make contact with the stone audible to the ear are interesting devices, but of no practical assistance.

Exploration with Litholapaxy Pump.—Bigelow pointed out the value of the evacuating pump as a searcher for small stones that elude the sound and lithotrite. Small calculi that are free in the cavity of the bladder are either drawn out by the pump, or, if too large to pass the tube, are drawn against its orifice with a click which is easily recognized.

One source of error is to be noted: namely, if the bladder wall is suddenly sucked against the tube, the shock may stir some of the joints of the apparatus and cause a click very like that produced by a stone. The expert hand usually recognizes the soft thud of the bladder wall, and, if the bladder is then a little more tensely filled, the wall is no longer drawn against the tube and the click is not repeated. Air in the evacuator may cause a bubbling which makes the perception of a slight click difficult.

Examination with the Cystoscope.—Usually the presence of a stone may be determined by simpler methods of examination. It sometimes happens, however, that small calculi escape detection by the sense of touch and cannot be easily seized by the lithotrite in an unanesthetized patient. In such cases the cystoscopic examination is most valuable, and often detects the cause of the unexplained bladder irritation. Encysted calculi may also be thus detected as well as incrustations of the bladder walls.

Besides the immediate recognition of the stone, much may be learned through the cystoscope as to the other conditions of the bladder (sacculation, prostatic outgrowth, or other new-growths) which will be of value in leading to a proper selection of operation.

x-Ray Examination.—Under some conditions a radiograph may serve a good purpose. If a stone is so buried in a pocket that it does not project into the vesical cavity, it may be impossible to discover it by other means. The existence of an opaque foreign body serving as the nucleus of a stone may be thus determined.

The surrounding bony walls sometimes make this examination a difficult one, but by so arranging the exposure that the rays traverse the pelvis in a direction parallel to its axis satisfactory results may usually be obtained.

Digital Exploration of the Bladder.—It must be a rare occurrence for a stone to escape detection by the methods of exploration already described. Occasionally, however, it may be so concealed in a pocket that it can neither be touched by a searcher, drawn out by a pump, nor seen with a cystoscope. The female bladder in such case of doubt can be explored by the finger introduced through the dilated urethra. The male bladder can be similarly examined by the finger introduced through a median perineal incision into the membranous urethra and so through the prostatic urethra. For the purpose of this examination the bladder

should be empty so that all parts of its wall can be brought down against the examining finger. The other hand pressing above the pubes makes this bimanual search a very thorough one.

The disadvantage of this method of examination is that the perineal route is a narrow one and does not afford room for any considerable manipulation within the bladder. If, therefore, a sacculated stone is found, it is probable that a suprapubic incision will be needed to enable the operator to properly deal with it. Moreover, in a fat man with deep perineum or where the prostate is much enlarged it may be impossible to reach the bladder through the perineum. For these exceptional cases a suprapubic incision is required for thorough examination. Through this opening the whole bladder can be readily explored and sufficient room is afforded to properly handle any condition found.

Treatment.—The consideration of the treatment of stone in the bladder may be properly divided into: (1) Preventive treatment; (2) solvent treatment; (3) operative treatment.

Preventive Treatment.—The presence of calcareous material in the urine or the occurrence of renal colic may give the warning which leads to the adoption of preventive measures. Again, in the presence of considerable cystitis with mucus it should always be remembered that such a condition is favorable to stone formation and measures should be at once taken to prevent this, if possible. Usually it is only after an operation for the removal of a stone that treatment is instituted to prevent its recurrence. The proper measures will depend upon the kind of a stone which has been removed or on the character of the sand which has been passed. In case of uric-acid or oxalate-of-lime stone the treatment must be directed to the constitutional condition which favors such deposits. These patients should observe the rules of diet suitable to a gouty or rheumatic individual.

Exercise is of very great importance. It should be sufficiently violent to give rise to perspiration. This stimulates the digestion, furthers the tissue changes of the body, and assists elimination through the skin.

The management of the bowels is of great importance in patients of gouty tendencies. Saline laxatives are thought to be especially efficacious. They are believed to act upon the liver as well as upon the intestines, and they are undoubtedly of great benefit in the treatment of patients of constipated habit with tendency to uric acid formation.

Patients having uric acid crystals in their urine should drink enough water to keep the urine in a tolerably dilute condition. It is well to take a considerable portion of this water between meals so as not to interfere with digestion. When in spite of all these precautions crystals continue to show themselves in the urine, it is wise to administer some solvent. Salts of lithia or of lithia combined with potash may be usually depended upon to accomplish this result. Piperazin is another powerful solvent of uric acid and is often of great service. When the tendency is to the formation of oxalate of lime crystals, the general treatment is the same as in the presence of uric acid. It is, however, also important to prohibit the use of fruits containing vegetable acid. Of these, rhubarb (rheum

ponticum), oranges, grape fruit, strawberries, and tomatoes are to be prohibited.

Phosphaturia of constitutional origin may usually be relieved by the exhibition of nitro-muriatic acid. A patient having this tendency should also be carefully instructed as to hygienic measures, exercises, and relief from care. When cystin is being eliminated in the urine, the use of carbonate of ammonia will usually bring about its disappearance.

When the tendency is to the formation of phosphatic stones secondary to local conditions in the bladder, the administration of urinary antiseptics which correct the alkalinity of the urine are of undoubted advantage.

Local Treatment Directed to the Prevention of Stone.—As there are many local conditions in the bladder which favor the formation of stone, it is evident that local treatment may often be of great service in preventing such formation.

The bladder which does not empty itself should be emptied with the catheter from time to time, or an operation to remove the obstruction should be done. If the residual urine shows a tendency to ferment and to become alkaline, the bladder should be carefully irrigated in order to remove the mucus and the crystals which deposit in it. When there is a suspicion that a concretion has started in the bladder, it is well to wash the bladder out with the litholapaxy pump under cocain anesthesia, or even without, in a patient not unusually sensitive.

Solvent Treatment of Stone.—We have no experience which gives us encouragement to attempt to bring about the solution of stone in the bladder. It is plain that only the smallest stones could be thus affected, and for these the litholapaxy pump offers so easy a method of removal that it is quite illogical to depend upon the slower effect of a solvent.

Operative Treatment of Stone.—Operations for stone in the bladder date back at least to the beginning of the Christian era. In the earlier operations the bladder was reached by incisions through the perineum. These were made without a guide. The stone was pulled down against the neck of the bladder by the fingers introduced into the rectum, and was then cut down upon. This method was especially adapted to children, but in favorable cases was applied to adults.

In 1533 the use of a guide in the urethra was introduced, and this gave the operation greater precision. Through a median incision in the perineum the urethra was opened, dilating instruments were passed into the bladder, and the prostatic urethra was stretched sufficiently to allow of the extraction of stones of moderate size. The need for more room soon led to incisions of the prostate being practised. Franco introduced the use of the concealed bistoury for the prostatic incision. Franco also was led in a difficult case to an incision above the pubes (the suprapubic operation). He did not recognize the value of this operation and it fell into disuse for many years.

The lateral incision in the perineum came into use about the beginning of the eighteenth century; and this was variously modified (bilateral, medio-bilateral, rectovesical, etc.), but without material increase of efficiency.

In 1824 Civiale crushed a small stone with a three-branched instrument introduced through the urethra. Even with this imperfect instrument he satisfactorily demonstrated the possibility of dealing with stones in this way. The form of the lithotrite was after this rapidly developed, and the operation of lithotrity became an established procedure.

In 1878 Bigelow introduced his operation of *litholapaxy*, which combined the thorough crushing and complete evacuation of the stone in one operation. At about the same time the introduction of aseptic methods and other improvements of technic so diminished the mortality of the suprapubic operation that it came to the front and gradually superseded the perineal incisions.

After this glance at the historical sequence of events in the development of stone operations we will proceed to a consideration of their applicability to patients with stone under varying circumstances.

General Considerations Affecting Choice of Operation.—Many surgeons when dealing with a stone in the bladder make choice of the operation with which they are most expert and for which they have the proper surgical outfit. For this reason many patients are subjected to cutting operations for whom litholapaxy would be more appropriate and safer. This practice is unfortunate and can never give as good results as are obtained by the man who is equally expert in all methods, and who, appreciating the influence which varying conditions should have on his choice of procedure, decides each case for itself and selects the operation which best avoids the dangers surrounding that particular patient.

The question of comparative danger is not the only one to consider in choosing the operative procedure. The possible interference with the functions of the patient and the completeness of cure must also be taken into the account.

Comparative Danger.—The rates of mortality after any of these operations vary greatly with the age of the patient. The death-rate in children and young adults after any operation on the bladder is less than it is in advanced life. For the purposes of this study, therefore, cases should be grouped in three categories: (1) Children to the age of fourteen; (2) adults from fourteen to fifty; (3) old men from fifty upward.

The ages of fourteen and fifty mark more or less accurately certain epochs in the development and decay of the genito-urinary organs. At about fourteen, the approach of puberty brings changes in the size and sensibility of these organs; and at fifty, senile changes in the bladder and prostate begin to appear and to interfere with the functions of those parts.

In the following table are given percentages of mortality which furnish a sufficiently accurate measure of the dangers surrounding each.

	Suprapubic Lithotomy.	Litholapaxy.	Lateral Lithotomy.
(1) Children under fourteen.	10 per cent.	1.66 per cent.	3 to 5 per cent.
(2) Adults fourteen to fifty.	12 per cent.	3.25 per cent.	11 per cent.
(3) Old men.....	15 to 20 per cent.	6 per cent.	26 per cent.

Interference with the Functions of the Parts.—Since the old perineal operations have been superseded by the suprapubic incision and by litholapaxy, it is rare to see any serious loss of function follow the removal of stone.

A *litholapaxy*, in a proper case, should never cause any lasting injury. Sometimes, in an old man with enlarged prostate, the instrumentation may so irritate the neck of the bladder as to lead to further congestion, and may even cause retention. This is only likely to occur in patients who already have a partial retention, and who are therefore close to the time when a catheter would be required in any event.

When retention follows a litholapaxy in this way, it stamps the case as one in which the relief of obstruction should have been aimed at, with the removal of the stone as a mere incident in this operation.

The *suprapubic incision* does not traverse important parts and rarely causes after-trouble. Occasionally a fistula remains, but this is usually a result of obstruction at the neck of the bladder and an indication that the operation was incomplete, in that it did not remove the obstructing condition.

The *perineal operations* entering through the neck of the bladder put the seminal ducts in jeopardy and by division of the sphincters may cause incontinence of urine. These results are to be feared only when extensive incisions are made in the neck of the bladder.

Persistent urinary fistula sometimes follows extensive perineal incision. Werewkin records this as occurring seven times in one hundred and forty-seven cases of lateral lithotomy in children.

Recurrence of Stone.—It is a not very uncommon experience to see recurrent attacks of stone. The formation of a stone in a bladder from which a previous calculus has been removed may come about in a variety of ways.

1. A uric acid stone may recur on account of the persistence or reappearance of the uric acid diathesis. An oxalic stone may be recurrent for a similar reason, as may also a phosphatic stone due to phosphaturia of constitutional origin. When cystin is present in the urine, the frequent appearance of small calculi is a characteristic feature of the disease.

2. The successive escape of several stones from the kidneys may give rise to consecutive attacks of stone in the bladder. These stones may be uric, oxalic, phosphatic, or composed of cystin.

3. A phosphatic stone may be reproduced after thorough removal if the chronic cystitis and alkaline condition of the urine persist. This is not uncommonly seen in those cases where an obstruction to the complete emptying of the bladder perpetuates the fermentation of the urine.

4. An ulcerated condition of the bladder favors the recurrence of phosphatic stones. The calcareous deposit forms on the ulcerated surface, and then, particles becoming detached, form one or many stones in the bladder. This is a common accompaniment of a projecting third lobe which is irritated by a catheter, or which, once excoriated by contact with a stone, remains ulcerated even after its removal.

Granulations projecting into the bladder along the line of a cystotomy

wound will similarly lead to successive stone formations. Tumors of the bladder wall also may furnish the nidus for repeated formation of calculi. I have seen one case in which a silver stitch left after the closure of a vesico-vaginal fistula led to successive stones, till it was found and removed.

5. Lastly, a fragment left after operation will serve as the nucleus for another stone. The danger of this mischance is greatly increased by any obstruction to the flow of urine, such as is caused by an enlarged prostate. The bladder in such cases is often sacculated, so that fragments escape removal by the evacuator after litholapaxy, or by the lithotomy forceps and scoop after lithotomy.

If such a fragment is left, it is unlikely to be voided by the natural efforts of the partially obstructed bladder. A healthy bladder that empties itself at each urination usually frees itself of such small fragments.

Completeness of Cure Following Different Methods of Operating.—It is plain that recurrences of stone due to the patient's diathesis, in which the new stone forms years after the removal of a former one, cannot be laid at the door of the operation. The same is true when successive escapes of renal calculi give rise to recurrent attacks of stone in the bladder.

When a recurrence of stone is due to a persisting cystitis, with consequent deposition of phosphatic material, the later stones cannot be ascribed to incompleteness in the operation, but rather to neglect in the after-treatment, which should follow the lines prescribed under "Treatment Directed to the Prevention of Stone."

A stone which has for its nucleus a fragment of an earlier stone is obviously the result of an incomplete operation.

It has been charged against litholapaxy that fragments are likely to be left in the bladder after it. The means of preventing this will be considered in the description of that operation. Suffice it to say here that the removal of the last fragment is easily accomplished in bladders having reasonably smooth walls. In much trabeculated bladders, or when an unusually deep pouch exists behind the prostate, it may be difficult, but is rarely impossible.

It is to be remembered, however, that the accident of a retained fragment is not peculiar to litholapaxy, for stones are often chipped or broken by the lithotomy forceps, and in an irregular or pouched bladder the thorough removal of every crumb is exceedingly difficult even through an ample suprapubic opening.

Finally, a cystotomy is not devoid of its own peculiar danger of stone recurrence from the deposition of salts on granulation tissue projecting into the bladder from the site of the wound. Even when the incision heals smoothly and kindly, there is usually a considerable time during which the moist wound surface offers a favorable nidus for the deposition of stone. Any calcareous matter which forms during this time falls, when detached, into the cavity of the bladder and serves as the nucleus of a stone after the wound is tightly closed. It has been my experience to see recurrence of stone after suprapubic cystotomy in at least as large a percentage of cases as after litholapaxy.

In most cases of recurrent phosphatic stone the surest cure is to be sought by relieving the obstruction which holds back a fermenting residual urine. A complete prostatectomy, which allows the bladder to thoroughly empty itself at each urination, will thus relieve a persistent tendency to recurrence of stone.

Much, then, has to be taken into consideration in determining upon the best operation for a given case. In childhood the mortality after any operation is small.

Litholapaxy is well borne, does no lasting injury to the parts, and is quickly recovered from. It should, then, be employed in all cases where the urethra will admit the instruments. If the stone is found to be too large to be grasped by the lithotrite or too hard to be crushed, the attempt should be abandoned and a cutting operation should be resorted to. The suprapubic operation injures no important parts and is therefore to be preferred over the perineal operations.

In adults litholapaxy is the operation of choice. It is the safest operation and most quickly recovered from. Under the following exceptional conditions litholapaxy is inadvisable: (1) A very large and hard stone may resist all reasonable efforts to crush it. (2) A stone may have as a nucleus a foreign body too hard to crush and too large to pass through a tube. (3) It may be impossible to grasp an encysted stone with the lithotrite. (4) False passages or a very large prostate may so interfere with the introduction of instruments that the dangers of the operation are greatly increased, and the question of lithotomy must be entertained. This is very exceptional, however, as a little care and patience in manipulation will usually overcome these difficulties. (5) The hip may be ankylosed in a position to interfere with the use of urethral instruments. (6) A stone may be so lodged in the prostatic urethra that it cannot be pushed back into the bladder.

A stone impacted in the prostate is usually best reached through a median perineal incision. In the other exceptional cases mentioned the suprapubic incision may be employed, although a small, hard, foreign body may be successfully removed through the perineum.

Complicating Diseases which may Modify our Choice of Operating.—Sometimes a general disease so increases the operative risk that it may be best to temporize. Diseases of the heart and lungs add to the danger of anesthesia. This added danger may be largely removed by appropriate preparatory treatment. In extreme cases a stone may be removed under local, even with spinal, anesthesia. Diabetes, Bright's disease, alcoholism, anemia, and gout are general diseases which add considerably to the risk of cutting operations, and in their presence we should especially incline to choose litholapaxy.

In interstitial nephritis with large quantities of watery urine litholapaxy has, in my experience, been well borne, whereas the mortality after cutting operations in these patients has been very great. Unfortunately, this condition, combined with dilated renal pelves and ureters, with often a superadded pyelitis, is a not infrequent accompaniment of stone. It is in just these cases that litholapaxy shows its superior safety.

The method of overcoming the difficulties which stricture of the urethra offers to stone removal are fully considered elsewhere.

Enlargement of the prostate usually adds but little to the difficulties of a litholapaxy. The instruments pass readily through it, and while the alterations in the shape of the bladder, notably the depression behind the prostate, somewhat hamper the operator, they do not prevent a satisfactory and thorough operation in the vast majority of cases.

When the enlargement of the prostate produces so much obstruction as to prevent the proper emptying of the bladder, we have a condition which itself demands correction. Under these circumstances the removal of the stone becomes a mere incident in the operation of prostatectomy. It is to be remembered, however, that the symptoms of prostatism are greatly aggravated by the presence of a stone. I have seen many cases in which a litholapaxy has so entirely relieved the prostatic condition that a prostatectomy which had before seemed inevitable was no longer thought of.

Preparation for Operation.—A young man with healthy organs requires little preparation. The exhibition of urotropin, or other urinary antiseptic, for a few days before operation is, however, a wise precaution.

When a man is old, with more or less inflammation of the urinary passages and with impairment of his kidneys, much may be done beforehand to better his chances of surviving an operation. He should be put in bed, carefully fed, and if the heart's action is in any way open to suspicion he should receive proper cardiac stimulation. The urine should be closely examined as to both quantity and quality. If the renal excretion is unsatisfactory, efforts should be made to increase its quantity by the exhibition of water to bring it to a proper amount. When the heart's action is feeble, digitalis and strychnin are needed, and occasionally nitroglycerin assists materially in promoting the flow of urine. If inflammatory conditions exist in the kidneys or if glycosuria is found, proper corrective measures should be adopted. Ammoniacal or putrid urine demands especial attention, as it is manifestly unsurgical to operate in an infected field. Urinary antiseptics should be freely given internally and the bladder should be irrigated systematically with cleansing solutions. For internal exhibition the benzoates, salicylates, boracic acid, urotropin, are the best. I have found it well to exhibit these at a time when the stomach is empty. They should be given with abundance of water. The bowels should be thoroughly opened by laxatives on the day before; and on the morning of the operation a small enema should be given and at once expelled to wash out the rectum.

Operation.—We have shown the crushing of the stone to be the operation of choice whenever it is possible, and we will therefore consider this method first, even though it is the most modern.

Lithotrity.—History and Development.—In early Arab writings the suggestion is made of rubbing down the calculus with a diamond fixed in a wire and thus introduced into the bladder. In 1580 Sanctorius suggested the possibility of extracting little calculi with three-branched

forceps. According to Haller, Sanctorius even proposed to use a stilet to perforate them when they were too large to be removed whole.

This suggestion of Sanctorius led to no practical results until Civiale, in the early part of the nineteenth century, produced an instrument which put the plan of Sanctorius to practical use, for Civiale's litholabe consisted of a three-branched forceps to hold the stone, with a stilet carried down through the shaft of the instrument which perforated and so broke it up. He operated successfully in 1824, and this was the first lithotrity of which we have any record.

In this same year Weiss constructed a lithotrite with curved blades on parallel shafts shutting together much like the blades of the modern lithotrite. In these early instruments the shafts slipped along beside each other and were insecurely fastened together, so that they sprung apart when any force was applied. To strengthen the shaft Heurteloup conceived the idea of making it of three pieces, the outer ones of which were attached to the female blade, and the middle one, which slipped up and down between them, carried the male blade. The two outside pieces of the shaft were joined in the lower part by a cross-rivet, and in the shaft of the male blade was a long slit through which this rivet passed —an arrangement designed to prevent the riding up of the male blade when pressure was brought upon the stone in its jaws. The force was supplied by the blows of a hammer. This arrangement of the shaft was not strong enough, and Costello added a button on the lower side of the shaft of the male blade, close down to the heel, which, overlapping the lateral pieces of the female shaft, held the female blade down and to a considerable extent prevented this riding up.

Costello, still not satisfied with the strength of the instrument, in 1832 devised and made a lithotrite in which the shaft of the male blade ran within a corresponding groove in the female blade. This final variation has been retained with slight modification to the present day. Costello's lithotrite was operated by percussion.

Various methods were then tried in the application of crushing force. The rack and pinion and screw power were quickly arrived at, and this latter has remained a favorite method up to the present time. To obviate clogging of the blades, the fenestrated female blade was later devised.

The early lithotritists, finding that the bladder was often unable to free itself of the fragments after crushing, devised various means for assisting evacuation. They endeavored at first to accomplish this by means of scoops and large catheters, to which they presently applied suction, either by a piston syringe or by the expansion of a rubber bulb. Clover's evacuating apparatus, which was the most developed instrument up to 1878, consisted of a large catheter, at the end of which was attached a rubber bottle, with a reservoir situated between the bottle and the catheter, into which the fragments gravitated during the pumping. This instrument, however, was not very efficient and its use was not generally approved. Gross, in 1876, says: "The practice of injecting the bladder to wash out the detritus is obsolete. . . This appa-

ratus of Mr. Clover should not be employed, if it is possible to dispense with it, as its use is quite as irritating as lithotrity itself."

French writers were almost equally strong in condemning the practice, and Thompson, holding a somewhat more favorable opinion, said in 1871: "Having used it (Clover's bottle) very frequently, I would add that it is necessary to use all such apparatus with extreme gentleness; and I prefer to do without if possible."

Surgical opinion was in this state then, in 1878, when Bigelow published his operation of litholapaxy, in which thorough crushing was combined with complete evacuation. This operation has now displaced the older methods and stands as the representative of them all. It is rare indeed now for a surgeon to plan the crushing of a stone without including in his operation the immediate evacuation of the fragments.

FIG. 188.—BLADES OF BIGELOW'S LITHOTRITE, OPEN AND SHUT.

Litholapaxy.—Bigelow derived the name of this operation from λίθος, "a stone," and λάπαξις, "evacuation." This name covers not only operations in which a stone is crushed and pumped out, but also those not infrequent cases in which small stones are pumped out without crushing.

Bigelow based his first attempts to crush and pump out a stone at one sitting upon the belief that inflam-

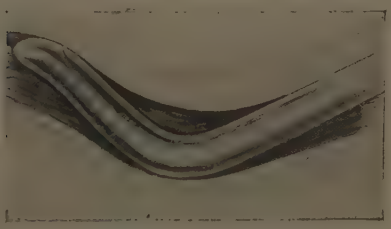

FIG. 189.—DIAGRAM OF URETHRA SHOWING BLADE OF LITHOTRITE SLIPPING THROUGH IT

mations following lithotrity were due rather to the irritation of retained fragments than to the contact of instruments during the operation. Experience has amply justified this belief. In introducing his evacuator he says: "In short, the evacuating apparatus and the evacuating method hitherto employed did not evacuate. This fact is beyond question." He devised a pump which does evacuate, and this revolutionized the operation for stone. We will consider, first, the alterations made by him in the lithotrite; secondly, the mechanism of the evacuator; and, finally, will consider the methods of using these instruments in the operation.

Lithotrite.—The alterations in this instrument were first in the blades, and second in the lock and handle. To provide a solid-bladed

lithotrite that should be self-clearing and could be used for an indefinite time without becoming clogged, Bigelow had the male blade made with a series of alternate, triangular notches, by whose inclined planes the detritus should escape laterally, after being crushed against the floor and rim of the shoe, or female blade.

To facilitate the introduction of this instrument, the point of the female blade was turned over and blunted. The advantage of this form in enabling the instrument to slip easily along the urethra is illustrated

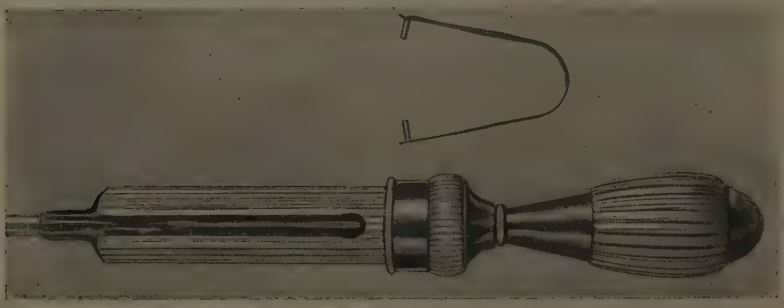

FIG. 190.—HANDLE OF BIGELOW'S LITHOTRITE, CLOSED.

in Fig. 189. The handle of the instrument was also modified in important particulars. In place of the wheel Bigelow substituted an egg-shaped, fluted handle of hard rubber that comfortably fitted the palm of the hand. Immediately below this handle he placed a revolving cylinder cap which, being held between the forefinger and thumb of the right hand, enables the operator to lock and unlock the instrument without changing his hold on the handle. A fenestrated instrument is more efficient than any solid-bladed lithotrite and should be used in reducing large hard stones.

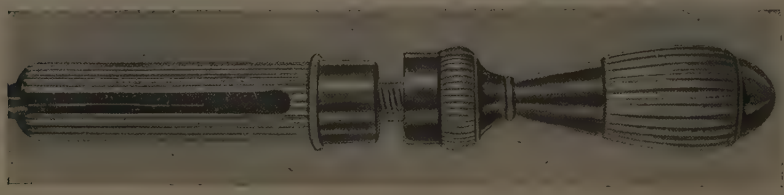

FIG. 191.—HANDLE OF BIGELOW'S LITHOTRITE, OPEN.
Showing the cylinder cap and the bars connecting it with the screw-guard. A half rotation of this cap, which is held in the finger and thumb of the right hand, locks the instrument.

After the calculus is divided into fragments, the instrument with the solid female blade may be taken for the further comminution of them.

Evacuator.—The essential parts of the evacuator are a tube or catheter, an elastic bulb to provide suction, and a receptacle for fragments. The number of combinations which can be made of these three parts is infinite. This is not the place to consider the forms adopted by different operators. The essential thing is to have sufficient suction, and the form in which this is supplied will vary according to the fancy of the surgeon.

For the sake of brevity, we will give a brief description of Bigelow's simplified evacuator, which was the form finally adopted by him. The evacuator consists, as has been said, of a tube, an elastic bulb, and a receptacle for fragments. For convenience of description the tube may be described as consisting of two parts: the movable part, or catheter, and the fixed part, which enters the bulb.

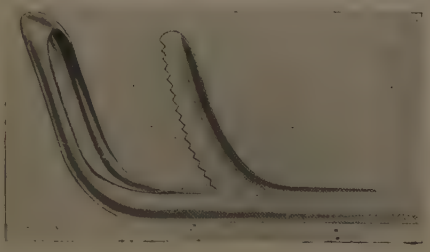

Fig. 192.—Fenestrated Blades.

The catheter may be either curved or straight. A straight tube offers less resistance to the passage of fragments, and is therefore better for the evacuation of them. The curved tube, however, is sometimes easier of introduction in difficult cases. At the upper end of the catheter tube is a projecting wing, which facilitates the handling of the instrument, and at the same time serves as a guide to the position of the mouth of the tube.

Fig. 193.—Bigelow's Simplified Evacuator.

The fixed portion of the tube extends obliquely upward to the center of the bulb. This tube is, for convenience, provided with a stop-cock just outside of the bulb, and if a second stop-cock is attached to the upper end of the catheter, the patient and bedding can be kept dry when coupling and uncoupling these tubes.

The portion of the tube which extends into the bulb is perforated all around with small holes, the aggregate area of which is larger than that of the opening at the end of the tube. The fragments rush into the bulb easily through this tube, while,

as the water is forced back into the bladder, it naturally seeks the shortest road and freest outlet through the perforations in the sides of the tube, which do not admit of the return of the fragments. The solid particles which are thus caught and retained in the bulb naturally gravitate to the bottom of it, where they are received in the glass ball or receiver, which can be readily removed and emptied. At the top of the bulb is an opening with a stop-cock to which a hose can be attached. This provides for the expulsion of air from the apparatus, and also for the easy regulation of the amount of water in the bulb and bladder during evacuation —a matter of great importance, as an overtense bladder is a source of danger and must be at once relieved; while a too empty bladder interferes greatly with the operation, as the lax walls are drawn into and obstruct the mouth of the tube.

In Bigelow's evacuator, as will be seen, the receiver in which the fragments are caught is at the extreme farthermost point of the apparatus from the bladder, and fragments once received in it cannot be again put in circulation and returned to the bladder.

The "simplified evacuator" has been still further simplified (Newell, Freyer) by leaving out the perforated portion of the tube which extends to the center of the bulb. Thus in this modification the fragments are separated by gravity alone.

The mouth of the tube should be as near the end as possible, and the form devised by Bigelow, with a projecting lip to prevent the mucous membrane from being sucked up against the orifice, has not been improved upon. The length and size of the tubes is a question of convenience, but obviously the shorter and larger tubes remove the débris more rapidly.

The Operation.—Small stones can often be pumped out without the necessity for crushing. If, after an attack of renal colic, a stone is not soon passed *per urethram* it is wise to wash the bladder with a litholapaxy pump. In such cases I have repeatedly removed little calculi which, if left, would have formed larger stones requiring a formal operation for their removal.

The crushing of a stone of moderate size may be done without anesthesia in a patient whose urethra is capacious and not sensitive. Cocain anesthesia greatly diminishes the pain of the manipulations and has been used in many litholapaxies. Chismore, of San Francisco, habitually operated under this local anesthesia. He used his combined lithotrite and pump, which requires less manipulation in the bladder than the ordinary instruments, for the fragments are drawn into the blades by the suction of the pump and do not have to be searched for. Usually, however, except in very easy cases, it is best to do the operation under general anesthesia. The relaxation of complete insensibility makes the manipulations much easier and adds greatly to the thoroughness of the operation. Especially important is it to allay the tendency of the bladder to spasmodic contractions, for this forces out the water and so reduces the space for manipulation of instruments, and it also subjects the bladder walls to a dangerous strain which, when the urethra is blocked, may lead to their rupture.

The first step in the operation is to empty the bladder with a large catheter. In doing this the urethra is explored for stricture and for any deviation caused by enlarged prostate or otherwise. If the meatus is narrow, it should be cut to at least No. 28 French.

The bladder is then washed out with sterile salt solution or with a 1 to 2 per cent. boric acid solution, of which from four to six ounces is left in the bladder. A light rubber tube tied around the penis, close to the corona glandis, will prevent the escape of fluid alongside of the instruments, thus serving the double purpose of keeping a known quantity of water in the bladder and of avoiding the wetting of the patient.

Before each introduction of an instrument the urethra should be filled with liquid vaselin or other aseptic lubricant to lessen as far as possible the friction.

The lithotrite is an easy instrument to introduce. Its short beak gives it some of the advantages of a coudé catheter and its tip runs along the roof of the urethra, where it is not likely to catch. After the beak passes below the pubes the handle should be brought to a vertical position, and the instrument then drops by its own weight, until the point rests just in front of the triangular ligament. If the point is now lifted slightly out of the depression it has made in the bulbous urethra, and if the handle is brought down between the thighs, the instrument being pushed gently forward in the axis of the body slips easily into the bladder. The passage of the lithotrite into the deep, fixed portion of the urethra is facilitated by strong traction on the penis, which stretches the walls of the urethra, straightens the folds, and helps to efface the depression just in front of the triangular ligament.

The places where difficulty may be met are at the triangular ligament and at the prostate. The point of the instrument may catch on the upper or lower edge of the comparatively rigid opening in the triangular ligament. If the handle is depressed before the beak of the instrument is carried down as far as it will go toward the rectum, the point is likely to catch against the upper edge of this opening; while, on the other hand, if the instrument is pushed too forcibly toward the sacrum, the lax, bulbous urethra is depressed below the aperture, and the point catches on the lower margin. Practically, if the instrument catches at the triangular ligament, it should be passed down with the beak hugging first the roof and then the floor of the urethra, and in one or the other of these ways it will usually find its way through. The finger pressing against the convexity of the curve of the instrument in the perineum will often lift the point over the lower margin of the opening when it is catching there.

A similar difficulty may be met with at the opening into the prostate. This happens but rarely, and is to be overcome by the same tactics. In cases of much difficulty the finger introduced into the rectum serves as a good guide, and with it the point of the instrument may be lifted into the prostate when it is catching on the lower edge. An enlarged prostate is, as a rule, easily passed by the lithotrite, whose short, curved beak carries the point along the roof of the canal, where it rarely meets an obstacle.

False passages may add greatly to the difficulty of the introduction of

instruments. A single false passage, if its position is made out, may usually be avoided by carrying the instruments along the opposite wall of the urethra at that point. If, however, several of these pockets exist, in which the instruments are caught, it will perhaps be a wiser plan to resort to lithotomy. When the lithotrite reaches the bladder, it is usually not difficult to find the stone which rests upon the floor of the bladder, and, with the patient in a horizontal position, is usually found at a point a short distance behind the prostate.

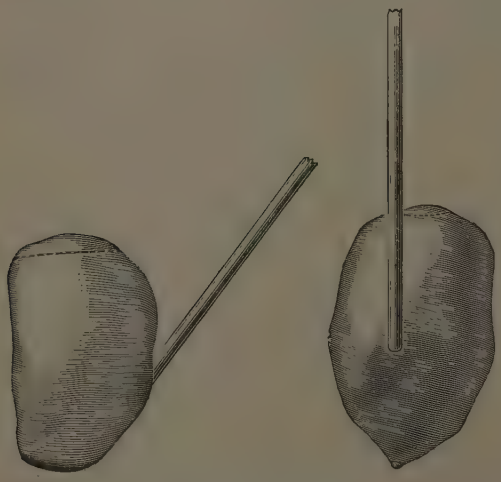

FIG. 194.—A CAST SHOWING THE SHAPE OF THE BLADDER WITH AN INSTRUMENT DEPRESSING THE FLOOR.

The operation of crushing demands patience, some skill of manipulation, and is greatly assisted by an accurate knowledge of the contour of the bladder, and of the changes in shape which may be impressed upon it by varying conditions of the surrounding organs.

The bladder when moderately distended is oval, somewhat flattened from before backward, and with its long axis nearly perpendicular. The lithotrite when pressed down into the floor of the bladder rests at one end of this long axis, so that the stone falls by gravity onto its jaws, which lie in a funnel-shaped depression. The shape of this depression may be somewhat altered if the rectum is filled with feces, and it is to avoid such distortion that the bowels should be thoroughly emptied before the operation.

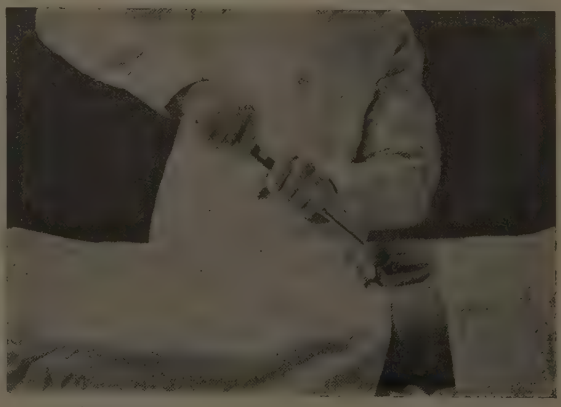

FIG. 195.—METHOD OF HOLDING LITHOTRITE WITH BLADES RESTING ON FLOOR OF BLADDER DURING ORDINARY CRUSHING.
Notice the right forefinger and thumb holding the cylinder cap which throws the screw in and out of gear.

In a normally shaped bladder, then, if the beak of the lithotrite is carried to the floor and then opened, a stone falls upon the shoe or female blade and is, therefore, seized as the male blade is again closed down.

If this maneuver does not succeed, it may be due to the fact that the floor of the bladder is unusually flat, so that the stone lies to one side of the blades, or it may be because the stone for some reason cannot fall down into the depression made by the instrument. Outgrowths from the prostate may so distort the floor of the bladder as to make it difficult to seize the stone.

A projecting third lobe may so narrow the depression in the floor of the bladder that the stone cannot fall into it. The lithotrite may enter the bladder on one side of a pedunculated third lobe and the stone may lie on the other side of it. The stone may even lie in a deep post-prostatic pouch where the lithotrite cannot reach it.

In view of these difficulties arising from prostatic outgrowths it is well to put these patients in the Trendelenburg position before beginning the operation. The effect of this position is to roll the stone backward away from the prostate into a part of the bladder where it can be easily reached and crushed.

Fig. 196.—Method of Holding Lithotrite when Turning the Blades over into the Left Side of the Bladder in Search for Fragments.

In a difficult case the finger in the rectum may be used to push the stone out of the post-prostatic pouch. When the stone is too large to fall into the depression in the floor of the bladder, the blades must be raised to seize it. This is done by depressing the handle of the lithotrite between the thighs. An enlarged third lobe of the prostate will assist to hold the stone up off the floor of the bladder. I have heard a stone lying thus high in the bladder described as being attached to the upper wall, but am convinced that the above is the correct explanation of the position of these high lying stones.

After such a stone has been crushed once or twice the fragments fall to the bottom of the bladder, where they are readily dealt with.

In crushing the stone, if the bladder is properly filled there is little or no danger of nipping the walls as long as the blades are operated in an upright position. When the blades are rotated toward the side walls or the floor of the bladder, more care is necessary. A very little experience will enable the operator to distinguish the soft resistance of the bladder wall, and if after seizing a fragment he always rotates the blades from side to side, to be sure they are free before finally screwing down, he will be quite safe from any danger of injuring the bladder walls.

The stone should be crushed as thoroughly as possible at the first introduction of the lithotrite. If the stone is large, the fine fragments will presently fill the bottom of the bladder so that the larger fragments

can no longer fall into the jaws of the lithotrite. It is now time to use the pump.

When the fragments do not fall readily into the jaws of the lithotrite, the beak must be turned first to one side and then to the other in search of them. When thus searching for fragments the blades should be opened in an upright position in the middle line and then turned over so as to lie flat on the bladder wall and shut along it.

When, finally, no more fragments can be caught, the lithotrite should be firmly screwed together and withdrawn. If there is any difficulty in fully closing it, the jaws may be carried to the center of the bladder and there, with the screw, may be opened and shut a few times to work out the impacted stone from between them.

Now comes the second part of the operation—evacuating the fragments. For this a straight tube is preferable, as it is more easily turned in the bladder when the operator wishes to direct the orifice toward different portions of that viscus. The introduction of a straight tube is not difficult if the anatomy of the urethra is borne in mind. It should be passed down in a vertical direction until it will go no farther toward the rectum. Then, being brought to a horizontal position, it should be gently pushed upward in the axis of the body. At the moment of bringing the tube down between the thighs, pressure should be made over the pubes in order to relax the suspensory ligament of the penis. Before advancing the instrument horizontally it is well to withdraw it very slightly in order to disengage its point from the pocket in the bulbous urethra. A slight rotation of the tube from side to side will help its passage through the triangular ligament.

FIG. 197.—COUDÉ END OF STRAIGHT TUBE.
This is the best tube for general use.

When there is much enlargement of the prostate, the tube sometimes has to be carried low down between the thighs in order to enable its point to ride over the prostate into the bladder. If the straight tube does not pass readily, a tube with the point slightly turned up, after the manner of a coudé catheter, may be tried. If this fails, the curved tube may be used as a last choice.

When there is much débris, it is well to commence pumping with the point of the tube held a little above the floor of the bladder. The object at this time is to set the fragments whirling and to catch them while they are suspended. If the end of the tube is buried too deeply in the detritus, it is apt to be clogged at the outset and the evacuation is thereby considerably hindered. Later, when the fragments are few, the tube is

carried to the floor of the bladder, and a few moments should elapse after pressing the bulb to give the fragments time to settle about the end of the tube before the expansion which is to suck them into it.

The wedging of a fragment in the tube causes an obstruction which is very noticeable; the compression of the bulb is rendered difficult and its expansion slow. The fragment thus caught in the mouth of the tube may be dislodged with a stilet, or with care the tube may generally be drawn out with the fragment in it.

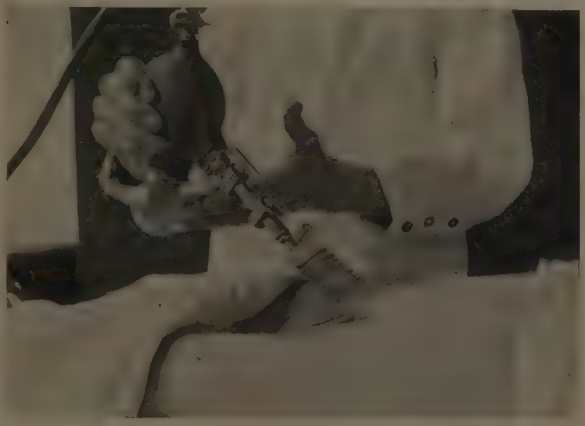

FIG. 198.—METHOD OF HOLDING THE BULB DURING ORDINARY WASHING.
The left hand supports the weight of bulb while the right hand pumps.

The tube may also be obstructed by the bladder wall, which is sometimes sucked into the orifice. When this happens, the jerk which it gives reminds one of a fish bite. If this occurs when the tube is held near the center of the bladder, it shows that the bladder is not sufficiently distended, and water should be added through the hose at the top of the bulb.

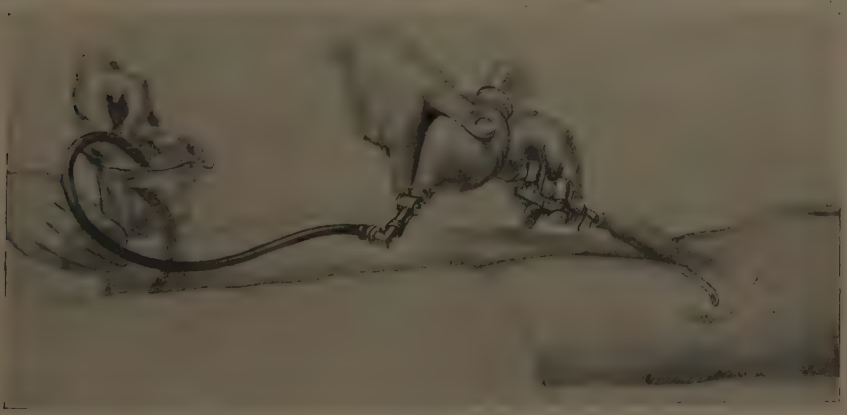

FIG. 199.—THE METHOD OF INVERTING THE BULB TO WASH OUT THE POCKET BEHIND THE PROSTATE.

Pumping should be prolonged until the fragments cease to come; the lithotrite should then be again introduced and the crushing continued. In using the pump for removal of the last fragments, it is important that the orifice of the tube shall be systematically turned in all directions in order to wash out any side pockets or corners in which fragments may

lurk. The pouch behind the prostate should be especially attended to in this way.

It sometimes occurs that a last fragment clicks and will not come through the tube, and yet is very difficult to find with the lithotrite. Under such circumstances I have found it possible with a little care to draw the fragment to the tube and to leave it close to the urethral orifice so that the lithotrite easily catches it at the next introduction.

In the search for this last fragment the Chismore lithotrite, in which the shaft of the male blade is hollow and has an aspirating bottle attached to its upper end, serves an admirable purpose. If, when the blades are slightly separated, suction is applied, the fragment is drawn between the jaws and easily crushed on the closure of the instrument.

When we are convinced that the stone is wholly removed, the urethra should be thoroughly washed out through a catheter of small size for the purpose of removing such fine sand as may have lodged in it.

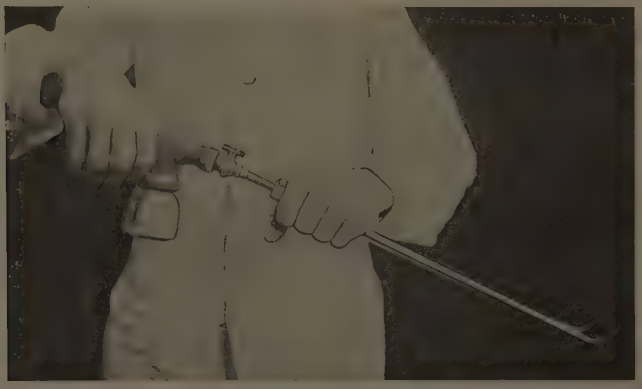

FIG. 200.—CHISMORE'S LITHOTRITE.

The shaft of the male blade is a tube, through which small fragments can be pumped. When the blades are partly open and suction is applied, the fragments are drawn between the blades and then crushed when the instrument is closed. This figure shows the method of holding the instrument while pumping to draw fragments between the blades.

After-treatment.—If the patient has been able to urinate normally before operation, we should continue the treatment which we pursued in preparation before operation, with liberal allowance of water and urinary antiseptics when necessary. When, however, there is obstruction of the urination, due either to enlargement of the prostate or to stricture of the urethra, it is usually well to fasten a catheter in for the first few days and thus provide for thorough drainage of the bladder. Since I have made this a rule I have not been troubled by chills following the operation.

At the end of ten days or a fortnight the bladder should be washed with an evacuator to remove any sand or gravel that was left at the time of operation. In some cases the tendency to formation of phosphatic concretions is so great that repeated pumping at intervals of ten days will continue to remove little calculi until the alkaline tendency of the urine has been overcome.

The operator should not be content until he has a satisfactory washing

without obtaining calcareous material. A small tube can be used for these subsequent pumpings and they can be done with reasonable comfort without anesthesia.

Complications Which May Arise During Litholapaxy.—*Hemorrhage.*—A slight amount of bleeding not uncommonly accompanies the operation. It is more common in old men, when the prostatic urethra is congested. It does not often cause any trouble and soon ceases.

There is rarely any bleeding from the bladder walls, unless they are ulcerated, and when any amount of hemorrhage occurs in the vesical cavity, it will cause a strong suspicion of the existence of a tumor, in which case the washings from the bladder should be carefully saved and examined for bits of new-growth.

Injury of the urethra is usually slight, and is to be avoided by gentleness and patience in passing the instruments. If, owing to previous false passages, any appreciable injury is done to the urethral walls, it is usually well to fasten in a catheter after the operation to prevent the urine from coming in contact with the abraded surfaces.

Rupture of Bladder.—If the bladder is overdistended, there is a possibility of rupture of its walls. Such a rupture is more likely to occur in a bladder with thin-walled diverticula. It is especially to be feared when the bladder shows a tendency to spasmodic contraction, for if under these circumstances the urethra is blocked with instruments, the tension may be very great.

The only case of the sort that I have seen was in a much contracted diverticulated bladder which had at the time about two ounces of fluid in it. In this case the rupture took place extraperitoneally on the left side of the pelvis and drainage was provided for the escaping urine by an opening above Poupart's ligament on the left, with eventual recovery.

When, during operation, the bladder is affected by violent spasms, the operation should be delayed until the anesthesia puts a stop to this. When a spasm occurs during the pumping, the tension can be at once relieved by opening the stop-cock at the top of the bulb and letting out the excess of water.

Impaction of fragments in the urethra is much less common than might be supposed. I have met with it once in a long experience, and in that case found no difficulty in pushing the fragment back into the bladder at the next introduction of the tube.

Clogging and Breaking of the Lithotrite.—A tough foreign body may resist complete crushing and become entangled in the jaws of the lithotrite. I have met with one case in which a leather shoestring formed the nucleus of a stone, and another in which a portion of an English silk-webbed catheter gave a little trouble. In both cases it was found possible to cut these up into sufficiently small pieces to be readily drawn out with the lithotrite and sucked out through the tube. When the blades are not easily freed they should be carried to the center of the bladder, and there should be many times opened and shut with the screw in order to gradually grind up and cut through the offending body.

Twists or fracture of the blades of a lithotrite should never occur in a

well-made instrument. The fact that such accidents are possible should lead the surgeon to discard any but the best and well-tested instruments. In a properly made lithotrite the blades will withstand any amount of force that the human hand can exert through the handle of the instrument. The size of the handle should bear a safe relation to the strength of the blades and shaft.

Perineal Lithotrity.—The old operation of perineal lithotrity with elaborate technic and powerful lithoclasts (Dolbeau, Rigal) is a thing of the past. Harrison and Keith have advocated this route for the introduction of the more modern crushing instruments, but the operation has not been extensively adopted.

It sometimes happens that a stone forms in the bladder behind a tight perineal stricture which requires an external urethrotomy for its proper treatment. Under these circumstances I have resorted to perineal lithotrity and, after incising the urethra, have introduced the lithotrites and tubes through the perineal opening.

With the patient in the lithotomy position, the instruments are easily guided through the short posterior urethra, and when in the bladder have a much freer mobility than when manipulated through the whole length of the urethra. The operation is easy and most satisfactory.

It will be found that usually the handle of the lithotrite must be held almost vertical in order to bring the heel of the female blade down onto the floor of the bladder.

When spasmodic contractions expel the water through the short, wide opening, the pressure of an assistant's finger below the instrument will keep enough water in the bladder for the proper performance of the operation.

Lithotomy.—Cutting operations for the removal of stone are of great antiquity. The perineal operations date back at least to the beginning of the Christian era. The earliest operations through the perineum were done without a guide, and when Celsus wrote the first detailed report of the operation that we now have, it was already an old operation, the technic of which had been passed along from one operator to another for many generations. In the operation described by Celsus the stone was pulled downward by the fingers in the rectum and was then cut down upon through the perineum. The incision employed appears to have been either transverse, bilateral, or lateral, and the bladder was entered either through its body or through the prostate, according to accident. This is the method known as "cutting on the gripe," the *apparatus minor*, so called because but few instruments were required. Celsus recommends this operation only for children from nine to fourteen years of age.

Eginus describes what is practically the same operation done through a lateral incision. According to him, the bladder should be opened through the neck, for wounds of the bladder wall do not heal satisfactorily. He speaks of the operation as applicable to all ages.

An old variation of the perineal operation consisted in plunging a sharp director into the bladder through the ischiorectal fossa and then

passing the blade of the bistoury along the groove, and with it making an incision of the required length. This operation was so dangerous as never to have come into good repute.

After these early descriptions surgical literature is silent in regard to lithotomy—a fact which suggests that it was not accepted by the authorities, but was relegated to specialists and empirics. In the year 1533 Marianus published a description of the operation known under the name of the *apparatus major*, on account of the larger number of instruments required. This operation was not original with him, but his description is the first reliable one that we have of it. It was a distinct advance over the operation of "cutting on the gripe" in that a grooved staff passed through the urethra was used as a guide and gave the operation greater precision. The operation of Marianus consisted in a median incision opening the deep portion of the urethra, through which the neck of the bladder was stretched either by a two-branched dilator or by the introduction of a gorget. It was practically the operation now known as the "boutonnière," and differed from the later median operation in the fact that the prostate was not incised.

Franco later modified it somewhat and added the use of a concealed bistoury for incision of the prostate.

While the perineal operation was in this stage of its development, Franco was led by necessity imposed by a very large stone to adopt the incision above the pubes, and thus became the inventor of the suprapubic operation, of which, however, he did not recognize the value.

At the beginning of the eighteenth century Frère Jacques operated after a method which he had learned from an itinerant lithotomist. In this operation the incision through the perineum was made at the left side and the operation was done upon a staff in the urethra. He first employed a round staff, but later adopted the grooved staff which had so long been in use for the median operation.

During the eighteenth century and the early part of the nineteenth, under the stimulus of success which now attended the operative treatment of stone, many surgeons sought to further improve existing methods and to discover still safer routes into the bladder. Frère Côme introduced the use of a concealed bistoury in the lateral operation, with the object of gaining mathematic exactitude for the deep incision. The cutting gorget was also used for the purpose of exactly limiting the incision in the prostate, and the blunt gorget was introduced to dilate the deep incision. These instruments were made in various shapes, and were much recommended by their inventors; but today most surgeons use the scalpel for the whole incision in the lateral operation, and it is rare that a lithotome or gorget finds its place in a modern armamentarium.

In the search for better incisions the notable modifications devised were the *bilateral operation*, published by Dupuytren, in which a semilunar incision with its concavity backward was made transversely across the perineum, and the prostate was incised with a double lithotome. The *medio-bilateral*, Civiale's modification of Dupuytren's operation, differed from it in that the incision through the skin was on the median line,

while the incision in the neck of the bladder was bilateral. The *recto-vesical* operation consisted in a median incision through the anterior margin of the anus and anterior rectal wall, and so into the bladder, either through the prostate or through the trigone just behind it. The mortality of this operation, and the frequency of troublesome fistulas which followed it, prevented its general adoption. None of these variations have proved to be of any especial value, and the median and lateral operations still hold their places as the best perineal methods.

While perineal lithotomy was passing through this gradual evolution, the suprapubic or high operation had various periods of favor and discredit. It proved its value for the removal of large stones, but showed itself to be much more dangerous than the perineal operations, and so did not succeed in displacing them for the majority of cases. Later, however, about 1878, such improvements were made in the technic of the high operation that it has now for the most part displaced the operation through the perineum, which is rarely used unless some coexisting condition, such as stricture of the urethra, enlarged and obstructing prostate, stone impacted in the urethra, demands a perineal incision for its proper treatment. The operation in such cases varies with the conditions and does not follow any prescribed form.

For this reason a formal description of the various perineal procedures is omitted here, and for a consideration of them the reader is referred to the older treatises.

It is well, however, to bear in mind that when the bladder is approached through the perineum, the rectum lies very close to the membranous urethra and prostate. If, therefore, these parts cannot be stretched to a sufficient size to permit the extraction of the stone, incisions made to enlarge the space should be directed almost horizontally outward, and not carried beyond the limits of the prostate. Incisions made downward in the median line through the vesical neck greatly endanger the rectum.

Stone Removal in Connection with Perineal Prostatectomy.—Any stone that is not extreme in size may be removed easily through the neck of the bladder after a perineal prostatectomy. The removal of the prostate leaves a large patulous opening through which the stone forceps or scoop can be easily manipulated. In one case I removed, with a lithotomy scoop, a dozen stones from one-half to three-quarters of an inch in diameter.

Young, having a stone too large to pass through the neck of the bladder, enlarged the opening by an incision out into the space from which one lateral lobe had been removed, and thus obtained space sufficient for the removal of a good-sized stone without interference with the functional result of the operation.

A stone too large for removal in this way can be crushed *in situ* and then be removed piecemeal, but when its size has been recognized before operation it may be well to select the suprapubic route, which can also be utilized for enucleation of the prostate.

Suprapubic Lithotomy.—This operation dates from 1561, at which time Pierre Franco successfully performed it on a young boy in

whom he found a stone too large to pass through his perineal incision. In 1580 Rousset theoretically worked out a plan of operation closely like the approved modern method, including distention of the bladder and raising of the pelvis so that the force of gravity should carry the intestines upward and draw the bladder up out of the pelvis.

This excellent plan was not carried out, however, and the operation fell into disuse. It was revived in the eighteenth century and used occasionally, but always with apprehension on account of urinary infiltration and consequent inflammation.

In the preantiseptic days too a wound of the peritoneum during this operation was almost certainly followed by death, so that the possibility of this accident was a constant deterrent to surgeons when any other route was possible.

Even the added exactness and security given by the sonde-à-dard of Frère Côme did not bring the operation into general use.

In 1878 Garson showed that the fold of peritoneum could be raised and the suprapubic aperture considerably enlarged by pressing the bladder forward with a distended rubber bag in the rectum.

Petersen applied this observation to the practice of suprapubic cystotomy, and this improvement, coming simultaneously with the general adoption of antiseptic precautions, gave the operation a new and secure footing.

Later still it has been found that if the patient is put in the Trendelenburg position, the full bladder sags upward by its own weight and widens the suprapubic interval sufficiently for safe operative approach.

Since these improvements the operation has steadily gained in surgical estimation. It is now the cutting operation of choice; affording, as it does, opportunity for the removal of the largest stones and for the thorough inspection of the interior of the bladder, so necessary in cases of sacculated stone. In many cases the stone formation is secondary to ulcerations or tumors of the bladder wall or projections from the prostate, and the suprapubic opening gives opportunity for the appreciation and treatment of these conditions.

Description of the Operation.—Under full anesthesia the bladder is washed and filled with a boric acid solution. The patient is then put in the Trendelenburg position, with the hips raised so as to cause the abdominal contents to fall away from the pelvis and to allow the bladder, drawn in the same direction by its weight, to separate the peritoneal fold from the pubes.

The operator stands on the right of the patient and makes a median incision three to four inches long just above the pubes. The recti and pyramidales muscles are separated by blunt dissection. Beneath the upper part of this opening lies the anterior fold of peritoneum, which is separated from the pubes by an interval which varies in different individuals from one-half an inch up to two inches.

A thin fibrous layer (fascia propria, Velpeau) connects the fold of peritoneum to the upper edge of the pubes. This fascia is often strong enough to hold the peritoneum down and to make it difficult to push it

upward out of harm's way before opening the bladder. All trouble may be avoided, however, if the fascia propria is separated by a transverse incision close to the edge of the bone. The left forefinger now draws this fascia, and with it the fold of peritoneum, upward and uncovers the anterior wall of the bladder lying at the bottom of the prevesical space (cavum Retzii). The vessels in the vesical wall can now be seen, and, avoiding them if possible, the bladder is opened by a direct thrust.

The left forefinger, which during this part of the operation has been holding up the peritoneal fold, is at once slipped through the opening while it is distended by the escaping fluid, and with it the conditions within the bladder are investigated. The aperture can then be enlarged either by stretch-

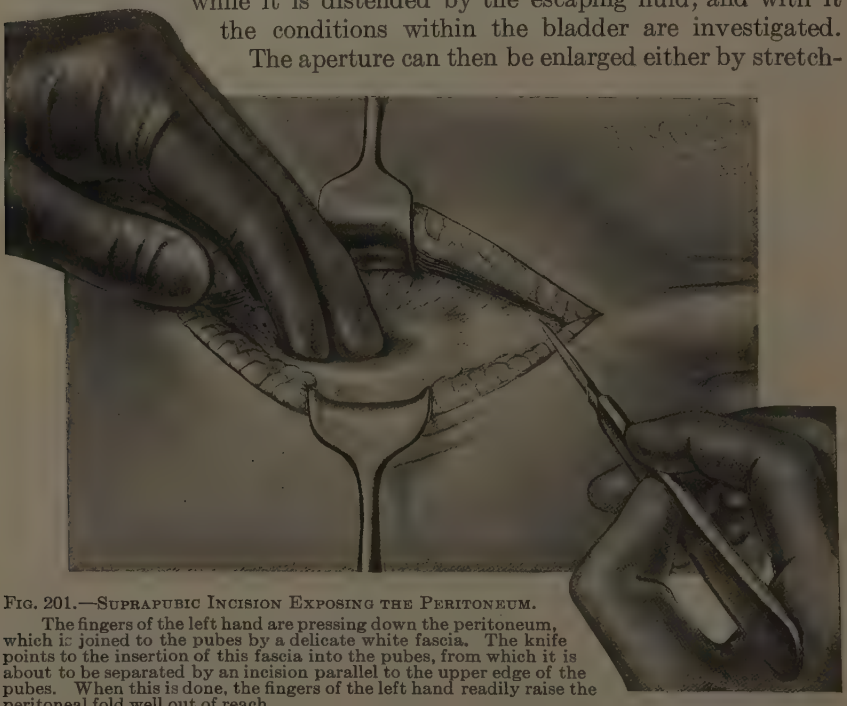

FIG. 201.—SUPRAPUBIC INCISION EXPOSING THE PERITONEUM.

The fingers of the left hand are pressing down the peritoneum, which is joined to the pubes by a delicate white fascia. The knife points to the insertion of this fascia into the pubes, from which it is about to be separated by an incision parallel to the upper edge of the pubes. When this is done, the fingers of the left hand readily raise the peritoneal fold well out of reach.

ing or with the knife. It should be sufficiently large to permit of extraction of the calculus without bruising of the tissues.

The forceps are now introduced on the forefinger as a guide, carried to the bottom of the bladder, where they are opened widely, rotated a half-turn, and then closed to grasp the calculus, which is then withdrawn. If there are many small calculi or if the stone is broken in the forceps, the lithotomy scoop (Fig. 202) affords the best means for their removal. Fine gravel and débris may be washed out with a stream of water directed to the bottom of the bladder.

The stone being removed, a careful search should be made to detect, if possible, the existence of sacculi in which stones or débris might lie concealed. If a sacculated stone is found, care should be taken not to severely lacerate the bladder wall in its removal. The opening should be

dilated as far as possible by gentle force, and if the stone cannot then be removed, it is perhaps better to crush and remove it piecemeal than to run the risk of urinary infiltration, which would attend any incision into the bladder wall. Any further operative measures, such as removal of a tumor of the prostate, may now be undertaken.

After-treatment of the Suprapubic Wound.—It is usually wise to arrange for drainage through the suprapubic wound. The opening in the bladder may be closed by suture snugly up to the tube, so that little or no leakage around it can occur. It is often wise to apply a second row of sutures so as to roll the bladder wall somewhat inward. When this is done, the opening left by the tube quickly closes when that is withdrawn.

It will sometimes be possible in an uninfected bladder to close the incision in its wall tightly and obtain first intention of the bladder wound. It is well, however, to place a gauze wick in the outer wound to act as a drain in case the bladder suture leaks. A troublesome extravasation of urine may thus be prevented. This wick should be wrapped in rubber tissue to make its removal easy; and it may usually be taken out at the end of forty-eight hours.

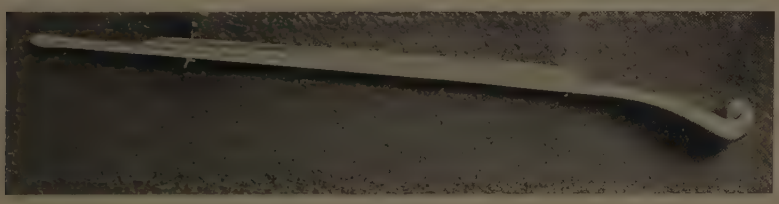

FIG. 202.—LITHOTOMY SCOOP.

If there is much hemorrhage into the bladder, this is to be looked upon as a contraindication to closure of the bladder wound, for if the urethra or catheter is stopped by clots, the effort of the bladder to free itself soon reopens the wound.

A continuous suture makes a tighter joint, and the edges of the bladder incision should be united by a continuous catgut suture. A soluble material is used for this suture, to avoid the danger of subsequent stone formation upon the stitch as a nucleus. After this first tight line of suture has been placed, the bladder wall may be still further rolled in by interrupted (Lembert) sutures. For these outside stitches, silk or celluloid thread may be used to give greater firmness.

Some operators have advised that the outer wall of the bladder be dissected off along the edges of the incision in order to prepare a fresh raw surface which shall readily unite when drawn together by sutures. This is, I think, a needless precaution.

Whatever plan is followed, great care should be taken that none of the stitches enter the cavity of the bladder, for if the urine finds its way along the stitches it makes first intention unlikely. The needle should take a good hold in the outer layers of the bladder down to the under surface of the mucous membrane.

Accidents and Complications in Suprapubic Lithotomy.—Rupture of the bladder has resulted from its overdistention. While more apt to occur in the weak, sacculated bladder of old men it has happened in children. If a rectal bag is used its pressure considerably increases the tension of the bladder. Rupture of the rectum has also resulted from a too zealous use of the colpeurynter.

The possibility of these accidents indicates the need of care in these minor details of the operation. If the peritoneum is wounded, this usually occurs during the first incision, and the rent can be tightly closed before the bladder is opened.

Stone in the Female Bladder.—The short and distensible female urethra affords a ready escape for small renal calculi that reach the bladder and for the sand and gravel that form there. On this account good-sized stones in the female bladder are a comparative rarity. Obstructions leading to residual urine are infrequent, so that this most fruitful cause of stones in the male bladder plays but a small part in the female. On the other hand, women are subject to hysteria, and the short urethra is favorable to the introduction of foreign bodies about which calculi may form.

It sometimes happens that large stones work their way by a combined dilatation and ulceration along the urethra and are spontaneously discharged. Stones as large as a goose-egg have thus escaped.

Incontinence usually results from such a stretching of the vesical neck, but sometimes stones four or five inches in circumference have passed with only temporary loss of retentive power. The vaginal septum is sometimes partially destroyed by ulceration due to pressure, and large stones thus find an exit.

The *symptoms* of stone in the female are not essentially different from those in the male; but they are sometimes complicated by uterine and other pelvic disorders.

The *physical examination* of the female bladder is an easy one. Through the vaginal septum a stone of moderate size may be made out by bimanual examination when the bladder is empty. With a finger in the vagina and a sound in the bladder all parts of the vesical cavity may be thoroughly searched.

Cystoscopy is easy in the female, and even digital examination through the dilated urethra is possible, though rarely necessary.

An *x*-ray examination is sometimes of value by determining the presence of a hairpin or other foreign body as a nucleus of the stone.

Operative Treatment.—Stones may be removed from the female bladder by: (1) dilatation of the urethra; (2) litholapaxy; (3) vaginal lithotomy; (4) suprapubic lithotomy.

Dilatation of the urethra may be used to give room for the removal of very small stones or of small foreign bodies. I have removed with dressing forceps through the urethra a silver stitch which had caused the formation of several stones before it was discovered and removed.

Litholapaxy.—This operation is easily performed in women, and is to be chosen for the great majority of stones. It causes no injury of

the parts and is quickly recovered from. With the patient in the lithotomy position the operation resembles a perineal lithotrity in the male.

In order to seize the fragments I have found it necessary to hold the lithotrite in an almost vertical position, so that the blades rest on the yielding vaginal wall close to the urethra. They then make a depression in this most dependent part of the bladder, into which the fragments gravitate and where they may be readily seized. For evacuation of débris a short and straight tube of good size may be used.

Litholapaxy is the operation of choice unless the stone is too large and hard to admit of crushing or unless it has a hard body as a nucleus. Also an encysted stone may elude the lithotrite. Under any of these conditions lithotomy may be required.

Vaginal Lithotomy.—This operation may be done with the patient in the dorsal lithotomy position or in the Sims position.

The bladder is opened on the tip of a sound which is made prominent against the vesicovaginal septum. This opening may be enlarged by scissors enough to provide for the removal of the stone. The wound in the bladder may then be closed by stitches, although small openings will heal spontaneously even when not sutured. During the healing the vagina and bladder should be constantly washed out to prevent phosphatic incrustation of the wound.

Suprapubic Lithotomy.—In case of a very large stone it will sometimes be wise to resort to the suprapubic incision for its removal; also, in children, before the vagina is sufficiently developed to give adequate room, the suprapubic operation may be used.

In one instance I removed a stone in this manner from a child three years of age, and after suturing the bladder snugly I provided drainage through an inlying catheter and obtained union by first intention. The steps of the operation do not differ from those already described in the male.

CHAPTER LIX.

SURGERY OF THE PROSTATE.

By Hugh H. Young, M.D.,

BALTIMORE, MD.

The prostate is an encapsulated musculoglandular organ which surrounds the urethra in its deeper portion and is in intimate relationship with the bladder, rectum, pubes, and perineum, besides other lesser structures, such as the seminal vesicles, vasa deferentia, Cowper's glands, etc. It is closely bound up by the ramifications of the pelvic fascias. It provides a thoroughfare for both the urinary and seminal canals, takes a most important part in both micturition and sexual intercourse, and is subject to both the ascending and descending maladies of these tracts, as well as to infections that reach it from its neighboring structures.

Anatomy.—The shape of the prostate is somewhat pyramidal, with the base against the bladder and apex at the membranous urethra. It is common to compare it with a horse-chestnut in shape. The organ has an apex, a base, an anterior, a posterior, and two antero-lateral surfaces, besides two postero-lateral borders, where the posterior and antero-lateral surfaces meet. The apex forms the lowest part of the organ, surrounds the urethra where the membranous portion begins, and rests upon the deeper layers of the triangular ligament, to which it is firmly fixed.

The whole anterior surface is convex, there being no definite line of demarcation between the anterior and antero-lateral surfaces. The posterior surface, which lies closely adjacent to the rectum, is slightly concave from side to side, in many cases presenting a distinct median furrow, and as the lobes extend higher upward laterally, there is often a well-pronounced notch in the base at the upper end of the posterior surface. The average dimensions of this surface are, from apex to base 3 to 4 cm., and at its greatest transverse diameter 4 to 5 cm. The antero-posterior diameter is about 2 cm.

The prostate is attached to the bladder by its base, which is so closely adherent anteriorly and laterally that no definite demarcation between the two organs is visible without dissection. Posteriorly, however, the base is well removed from the bladder and presents a definite border, which is in more intimate relationship with the seminal vesicles than with the bladder. The general configuration of the prostate is well shown in Fig. 203 (1, 2, 3, and 4), taken from dissections made by Richardson, and his views of a prostate, which has been freed, with its urethra, from the bladder, show very clearly the position of the urethra, the backward

trend of the lateral lobes, which thus extend up beneath the vesical trigone, and the short anterior surface with the urethra close behind it. Figure 1, a posterior view, shows the canal of the ejaculatory ducts, which enter distinctly beneath the upper margin of the posterior surface. Figure 2, a view of the base, also shows the remoteness of the ejaculatory canal from the posterior part of the prostatic urethra.

The relations between the prostate, the vasa deferentia, and the seminal vesicles are shown in Fig. 204. As seen here, the vasa and vesicles join to form the ejaculatory ducts, which enter the prostate in the upper

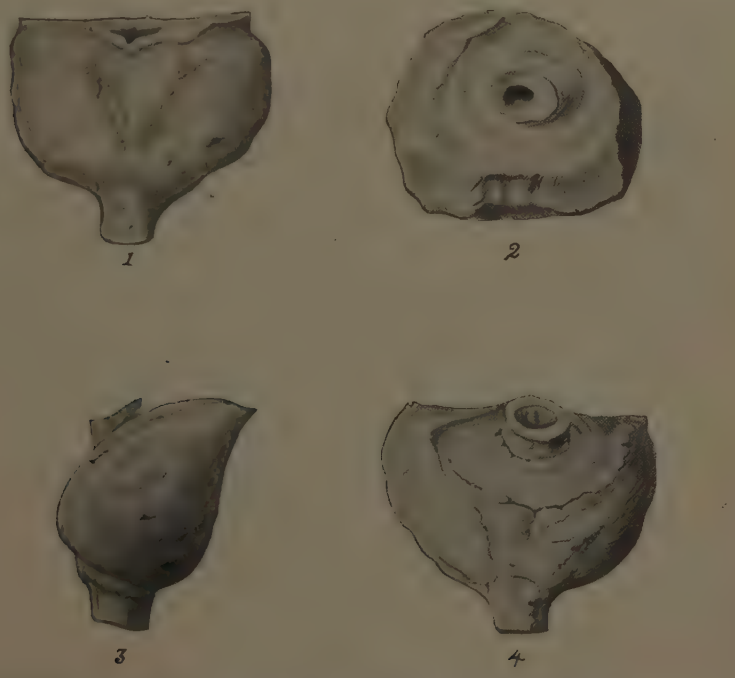

FIG. 203.—NORMAL ADULT HUMAN PROSTATE (Richardson).
1, Posterior surface; 2, base; 3, side view; 4, anterior surface showing vesical orifice and imprint of sphincter.

portion of the posterior surface and pass downward and forward in a fibrous canal which ends at the verumontanum.

The Capsule.—It is usual to describe the investing membranes of the prostate as composed of separate portions—the "capsule" proper and the "sheath." They are not, however, well defined and separate structures, but over much of the surface are so intimately blended as to be separated with difficulty. Richardson has shown that in animals there is a thin capsule, and outside of this a fascia in which the veins course. In men the fascias of pelvis and perineum have become condensed as a result of the erect posture and the consequent extra strain which has been placed on the pelvic floor. This union of the capsule of the prostate and the surrounding fascias has become so close that, in places, only by

following the venous plexus as a guide can the fascia (which contains the plexus) be separated from the capsule beneath.

The capsule then appears as a rough membrane except upon part of the lateral and posterior surfaces, where the separation of fascia and capsule is easily accomplished. The capsule covers the entire prostate, but it is very firmly attached and cannot be stripped off without bringing away portions of gland tissue. It is composed of fibrous tissue and involuntary muscle which are continuous with the glandular stroma.

The Surrounding Fascias.—The prostate is surrounded on all sides by aponeuroses which fix it to the middle of the perineum, forming what the French call the *loge prostatique.* Proust compares the prostate

FIG. 204.—VIEW OF PELVIS FROM BEHIND (Deaver).
Showing posterior surface of the prostate, seminal vesicles, vasa deferentia, and bladder. The aponeurosis of Denonvilliers has been partly removed.

encased in its *loge* with a tooth in its alveolus. These pelvic fascias are so complex that I have not the space to fully describe them, but those who are interested may consult the exhaustive treatises of Cunéo and Veau, Proust, Richardson, Deaver, Wallace and Albarran.[1] Suffice it to say that the prostate is surrounded and bound to the pubes, triangular ligament, bladder, rectum, and lateral pelvic walls by reflections of the rectovesical fascia, as shown in Fig. 205. This fascia springs from the white line, passes over the internal surface of the levator ani muscle, and divides into three layers: (1) a superior or anterior, which passes above the prostatic plexus of veins, over the anterior surface of the prostate, to which it is adherent as well as to the pubes; (2) a middle layer, which passes beneath the lateral prostatic plexus of veins and behind the pos-

terior surface of the prostate; and (3) a posterior layer, which hugs the anterior surface of the rectum. The last two layers are loosely attached to each other and constitute the aponeurosis of Denonvilliers. Anteriorly this fascia (rectovesical) is reduplicated and forms two strong fibrous bands known as the puboprostatic ligaments, between which is a space containing a venous plexus (of Santorini), to which the dorsal vein of the penis is tributary. The periprostatic plexus of veins is in reality incorporated in the anterior layer of rectovesical fascia, and Proust pictures two layers of this fascia between which the plexus lies, as shown in Fig. 205. Between the sheath and the capsule of the prostate are various fibrous communications which are more intimate anteriorly than posteriorly. Cunéo and Veau have shown that the aponeurosis of Denonvilliers, which is composed of the middle and posterior layers of the fascia described above, is derived from a downward prolongation of the peritoneum in fetal life which becomes obliterated later (Fig. 206). The serous surfaces disappear, but the fibrous coats remain and are easily separable. In approaching the prostate from the perineum it is necessary to divide the posterior layer, which is closely attached to the rectum, in order to expose the posterior surface of the prostate, to which the anterior layer of Denonvilliers' fascia is closely attached. This fascia is continuous below with the deep layer of the triangular ligament. From there it extends upward along the posterior surface of the prostate (as above described) and thence over the posterior surfaces of the seminal vesicles, the vasa deferentia, and the vessels and nerves accompanying them (see Fig. 204). It forms a fascia of considerable thickness and apparently acts as a definite barrier to the backward extension of malignant prostatic disease. The fact that the lymphatics and vessels extending upward from the prostate lie in front of and do not perforate it shows the importance of carrying the line of removal behind it in the operative treatment of cancer of the prostate.

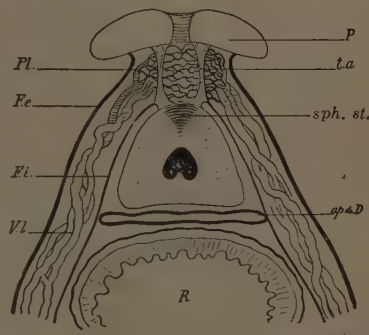

FIG. 205.—DIAGRAM OF THE LOGE PROSTATIQUE (Proust).

P, pubes; *Pl.*, plexus of Santorini; *t. a.*, puboprostatic ligaments; *Vl*, periprostatic veins; *F. e.* and *F. i.*, external and internal layers of sheath that incloses those veins; *sph. st.*, sphincter; *ap. de D.*, aponeurosis of Denonvilliers showing the two layers; *R*, rectum.

The fascia which covers the posterior wall of the bladder also has important relations with the seminal vesicles and prostate. At the upper ends of the seminal vesicles this fascia splits, one layer passing in front of the vesicles and ampullæ of the vasa deferentia and one behind. That which passes in front, between these structures and the bladder, passes downward until it reaches the prostate, upon the capsule of which it runs forward, separating this thin, superiorly projecting portion of the lateral lobes from the bladder. Toward the median line it accompanies the ejaculatory ducts within the prostate, forming the anterior part of their

fascial covering or "tunnel." That portion of the vesical fascia which passes behind the seminal vesicles also continues downward, forming the posterior covering of the vesicles and vasa and being incorporated and continuous with the fascia of the posterior surface of the prostate (apparently being inseparable from the anterior leaf of Denonvilliers' aponeurosis). Along the outer edge of the vesicles and along the inner edge of the vasa deferentia the two sheets of vesical fascia are united, thus forming an enveloping capsule on each side and binding these structures firmly against the base of the bladder.

Blood-vessels.—The dorsal vein after piercing the triangular ligament enters the fibromuscular tissue which lies in front of the prostate and between the puboprostatic ligaments. Near the upper part of the anterior surface of the prostate it divides into a right and a left branch which passes upward and backward on the surface of the prostate close to the bladder, where it is joined by veins from both bladder and prostate. Having arrived at the upper limit of the lateral borders of the prostate, these veins pass along the outer border of the seminal vesicles, receiving branches from the vesicles, vasa, and posterior surface of the bladder. Some veins from the posterior surface of the prostate run upward near the middle line, but they soon turn outward across the posterior surfaces of the vesicles to join the veins which course along the external borders. It is thus seen that all the blood from the penis, prostate, and bladder is poured into this periprostatic plexus, but it receives no blood from parietal structures.

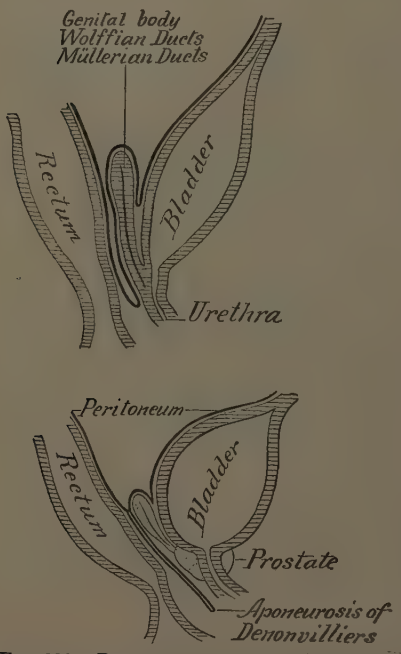

FIG. 206.—DEVELOPMENT OF THE APONEUROSIS OF DENONVILLIERS (Cunéo and Veau).

Arteries are furnished to the prostate by the inferior vesical, the middle hemorrhoidal, and the internal iliac. The branches which reach the prostate are small, and enter at the superior and lateral aspects of the gland. They divide into numerous branches which surround the glandular acini.

The lymphatics begin in rich networks around the acini. According to Sappey, four lymphatic trunks are generally present, an antero-lateral and a postero-lateral on each side. The antero-lateral lymphatic leads to a gland situated in the subpubic fossa near the iliac vessels. The postero-lateral leads to a gland along the lateral wall of the pelvis, or to a gland near the first iliac bifurcation. The lymphatics from the seminal

vesicles lead to two glands, one situated just above the upper end of the vesicle and the other farther back, along the lateral wall of the pelvis.

The nerves come from the hypogastric plexus, accompany the arteries, have ganglia scattered along their course, and terminate in the muscles and glandular culs-de-sac.

Relations to Parietal Structures.—The prostate is in relation to the triangular ligament and perineum below, the levatores ani at the sides, the pubes in front, the rectum behind, and the bladder and seminal vesicles above.

Those fibers of the levator ani beginning at the back of the pubis pass backward around the antero-lateral aspects of the prostate and unite beneath it, blending with the fibers of the superficial transverse perineal

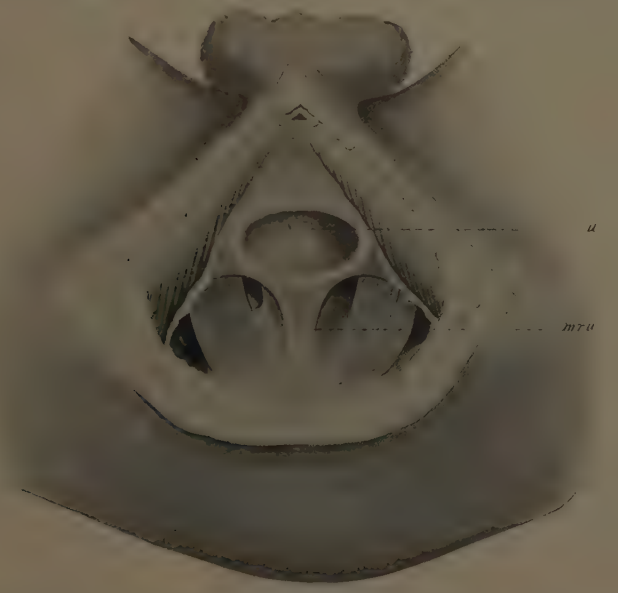

FIG. 207.—ANATOMIC PREPARATION OF THE PERINEUM (Proust).

The anterior superficial perineum has been completely removed. The urogenital triangle perforated by the urethra (*u*) and its junction with the recto-urethral muscle (*m r u*) forms the semilunar arch of the perineum.

and external sphincter ani muscle at the central tendinous part of the perineum. To this portion of the levator ani muscle Santorini has given the name of levator prostatæ.

Between the anterior part of the prostate and the rectum is a small muscle known as the recto-urethralis. It is attached anteriorly to the posterior border of the triangular ligament and the membranous urethra, and from there runs backward and is inserted into the anterior wall of the rectum. It is short and rather indefinite, but performs the important function of drawing the anterior part of the terminal portion of the rectum into a large *cul-de-sac, cap rectale,* or *vessie fécale,* as it has been variously styled by the French. Fig. 207, taken from Proust, shows the recto-urethral muscle, which is described by him as having broad attach-

ments to the triangular ligament and pronounced semilunar borders. The anterior portion of the levator ani muscles which encircle the sides of the prostate and membranous urethra are more or less fused with this recto-urethralis muscle, and at operation it is generally difficult to obtain the picture shown by Proust.

Between the recto-urethralis muscle and the prostate lie the two layers of Denonvilliers' aponeurosis, as shown in Fig. 208. This diagram shows the importance of dividing the recto-urethral muscle when approaching the prostate from the perineum in order to properly push back the rectum and have easy access to the space between the two layers of the aponeurosis of Denonvilliers.

Comparative Anatomy.—After a careful study of the prostate in various animals Richardson says: "In animals it is usual to speak of two prostates, because even when the two glands are united to form one mass, it is evident that the mass is composed of two portions, but in a great number of animals the two portions are entirely separate glands. Just as there are two seminal vesicles and two Cowper's glands, so there are two prostates, a right and a left gland. The prostatic ducts always open into that part of the urethra between the bladder and the bulb which is developed from the entodermal cloaca, and which is called a muscular urethra. Into this portion the vasa deferentia, seminal vesicles, utriculus masculinus also enter, and these ducts have the same relation to each other, the prostates always entering lowest, and on either side of the middle line." The prostates in animals vary from mere cecal diverticula, as in the guinea-pig, to a complicated racemose glandular structure similar to those in man. Richardson thinks that the prostate gland, seminal vesicles, and Cowper's glands have the same function in animals, viz., to provide a medium in which the spermatozoa can live. The comparative size of these accessory glands varies very greatly in different animals. In some the seminal vesicles are of huge size and the prostate and Cowper's glands insignificant, and in others the opposite is the case. Cowper's glands are always, and the prostates almost always present, but the seminal vesicles are often absent and replaced by enlarged vasa deferentia. In animals the prostates are never situated close to the bladder, as in man, but are appendages of the urethra, and in no way connected with the bladder. The utricle opens posteriorly in the median

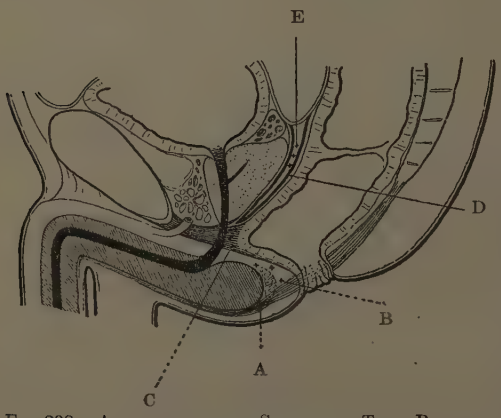

FIG. 208.—ANTEROPOSTERIOR SECTION OF TRUE PELVIS IN THE MALE (Proust)

A, Central tendon; B, space between bulb and rectum; C, recto-urethralis muscle; D, posterior layer of aponeurosis of Denonvilliers; E, space between the two layers of aponeurosis of Denonvilliers.

line of the urethra and nearest to the bladder of all the accessory ducts. On each side of the utricle are the orifices of the vasa deferentia. Still lower down, and at a considerable distance from the bladder, the ducts of the prostates open into the urethra on each side posteriorly. The fact that in animals the utricle enters the urethra in an entirely different level than the prostatic ducts shows that the prostate cannot be considered the homologue of the female uterus, which arises from the same fetal structure as the utricle, the Müllerian duct.

Histology.—The prostate consists of gland tissue surrounded by stroma which is continuous with the capsule, the urethra, and the bladder. Convergent strands of stroma extend from different points of the capsule

FIG. 209.—TRANSVERSE SECTION OF HUMAN PROSTATE CLOSE TO BLADDER (SLIGHTLY MAGNIFIED) (Richardson).

Shows capsule, stroma, sheath, anterior commissure, lobules of lateral lobes, separate lobules of middle lobe focusing on back of urethra, and the ejaculatory ducts.

and end in the urethra, thus dividing the prostate into a large number of lobules, each of which is in reality a separate gland, according to Richardson, and has its own secreting duct. The duct lies in the center of each lobule and receives the secretion of many small tubules which radiate from it. Between the tubules and the stroma is a layer of connective tissue containing the vessels and nerves, and upon this lies a basement membrane. Next comes the secreting epithelium, composed of columnar epithelium upon a layer of round cells. The walls of the acini are thrown into folds so that a large secreting surface is obtained. The tubules are closely and irregularly packed together except where gland tissue is scarce. The stroma consists of fibrous tissue, involuntary muscle, and a few elastic fibers.

The glandular tissue lies mostly on each side of the urethra, where it forms the two lateral lobes. There is very little glandular tissue in the anterior commissure, which is almost entirely composed of smooth muscle and fibrous tissue. Posteriorly gland tissue is found beneath the urethra, where it is separated into an inferior and a superior portion by the tunnel of fascia which contains the ejaculatory ducts. The superior portion is thus described by Richardson: "At the upper and posterior part each lateral glandular mass is united to its fellow of the opposite side by a collection of gland tissue which lies below the base of the bladder, behind the posterior wall of the urethra, and in front of the tunnel for the common ejaculatory ducts (Fig. 209). This mass of gland is called the third or middle lobe, or the median portion of the prostate. It is true that it is not completely separated from the lateral lobes, with which, indeed, it is structurally continuous on each side, but it is nevertheless different from the main masses of the prostate. Its anatomic position in the middle line seems to mark it off from the rest of the gland as a separate portion. When the vasa deferentia, the seminal vesicles, and the common ejaculatory ducts have been removed, it can be seen to project as a small mount on the posterior aspect of the prostate immediately above the depression for the seminal ducts, in the interval between that depression and the base of the bladder. This piece of gland lies under a different part of the urethra from the lateral lobes, viz., not under either prostatic sinus, but under a higher part of the posterior wall of the urethra immediately below the uvula vesicæ in that V-shaped area previously described. It is more commonly the seat of pathologic change than the rest of the prostate. It is often the only part of the organ which enlarges in old age, and when so enlarged it appears to be quite independent of the rest of the prostate. For these reasons it appears to merit a distinctive name; what that name may be is not of great importance, whether it be 'median portion' or 'third lobe' or 'middle lobe.' Whether its existence be denied or admitted, there is no escape from reference to it both in anatomy and pathology."

Abnormities and Cysts of the Prostate.—Probably the simplest method of classifying these conditions is along anatomic lines considering the abnormities of the prostate as a whole—of its separate lobes, of its structures normally present, of the structures embryologically associated with it, its cystic abnormities, and those of the closely related structures which may secondarily involve the prostate, or at least cause confusion in differentiation from those of the gland.

The **etiology** of the truly developmental errors of the prostate is explained by an interference in the normal building of the gland at some stage of fetal life. The persistence of certain embryologic structures closely allied to the prostate, which may secondarily undergo pathologic changes, the blocking, either developmental or pathologic, of normally patent tubules or ducts or of the sinus pocularis, the secondary involvement of the gland by abnormal conditions existing in proximal organs or regions—all may lead to conditions in the prostate far removed from the normal.

The **pathology** of these conditions is naturally as varied as the condi-

tions themselves. Where the error is purely developmental, no real pathologic condition can be said to exist. Simple arrested development will show the picture existing at the time the normal growth ceased.

Reports in the literature of anomalies of the prostate are not very numerous, and with the rarest exception are seen nearly always in connection with other anomalies of the genito-urinary tract. The close association, both embryologically and physiologically, of the testicle with the prostate, and the dependence of the latter upon the former for its proper functioning and development, make the prostate peculiarly susceptible to abnormities of the testicle. The large proportion of the abnormities of the prostate as a whole are associated with the condition of cryptorchidism. Here arrested development and bilateral atrophy of both lobes exist in varying degrees. Cornelli reports the case of a newborn in which there was complete absence of prostate, seminal vesicles, and utricle in association with cryptorchidism. Symmetric anomalies may exist in association with exstrophy of the bladder, the roof being entirely wanting, though the floor, according to Keyes, never fails in this condition. In cases of pseudo-hermaphroditism, absence or symmetric atrophy is prone to exist, while defective development has occasionally been noted in sexual perverts (Lydston). Changes in the prostate are also noted in association with the condition of parenchymal sclerosis of the testicle (Launois).

Launois reports several cases of monorchidism associated with marked arrested development of the corresponding lobe of the prostate and of the seminal vesicle of the same side, the opposite lobe and vesicle being normal. Viannay and Cotte have reported a case of congenital absence of kidney and ureter of the right side associated with absence of right seminal vesicle and ejaculatory duct and an atrophied right testicle and right lobe of the prostate.

Socin and Burckhardt lay stress on the condition to which Englisch first called attention, of *retention cysts* due to the closure of the urethral outlet of the sinus pocularis. In seventy autopsies on the newborn Englisch found this condition existing in over 7 per cent. Children in whom the first emptying of the bladder occurs on the second or third day, either spontaneously or by instrumentation, will show frequently at first, before the appearance of the urine, a few drops of a yellowish mucoid substance, the cyst contents, which have escaped by rupture. These cysts may even be large enough to encroach upon the rectum, where they may be felt, and probably some of the cases of enlarged sinus pocularis in adults are merely the remaining evidences of early cysts of this structure. Beraud reports a case of complete absence of the right half of the prostate, the vasa deferentia uniting above the prostate. Cases of atresia of the ejaculatory ducts, closure of their outlets, and dilatation of their blind endings, leading to marked increase in volume of the colliculus, and blocking of the urethra have been reported by Rindfleisch.

Lydston reports cases in which the urethra was situated laterally or pursued a markedly tortuous course in young adults. Congenital bands, transversely crossing the urethra, have also been noted.

Luschka reported a case in which well-defined tissue identical with prostatic tissue was present at the base of the penis, about 2 cm. in front of the union of the corpora cavernosa.

Cysts in the region of the prostate may also be congenital anomalies of the remains of embryonal structures, non-obliterated Müllerian ducts, and Wolffian bodies. Cysts arising from the seminal vesicles and the ducts may give rise to tumors in this region. Retention cysts due to the blocking of the gland-ducts may reach a comparatively large size, sometimes causing retention of urine.

Echinococcus cysts of the prostate have been described by Nicaise, Lodwell, Winterberg, Butreuille, Tillaux, and Millet, but, according to Durrieux, the great majority of echinococcus cysts of this region have arisen outside of the prostate.

Symptoms.—According to Durrieux, the symptoms of compression of the rectum and the bladder—retention, dysuria, constipation—frequently initiate the examination which leads to the discovery of the cyst. Catheterization for retention has led to the perforation of these cysts into the urethra and bladder. If large enough, the cyst may be felt both abdominally and per rectum, where it exhibits no signs other than those of a simple cyst. Puncture is diagnostic, but not without danger, owing to the great possibility of infection. Rupture into the bladder may lead to great pain in this region, hematuria, and frequency. Rupture into the rectum is associated with the danger of infection. The best mode of treatment seems to be evacuation and removal of the cyst via the abdomen, if possible.

Many of the other abnormities produce no symptoms other than those resultant from lack of sexual development. We have not the space to describe these at length or to dwell upon the surgery required.

Traumatisms.—The traumatic lesions of the prostate include contusions, injuries, and false routes. Although the bladder and urethra are frequently ruptured by injuries to the pelvis and its structures, the prostate itself is singularly free from injury. Albarran was able to find only one case, which had been cited by Velpeau, of an extensive perineal traumatism in which the prostate was studded with small hemorrhages. In fractures of the pelvis it is not infrequent for the prostate to be torn off from the membranous urethra. One such case occurred in my practice. Here a perineal incision disclosed a separation of three inches between the prostate and membranous urethra, the intervening space being filled up by a huge blood-clot. It is interesting to note that although the bladder was greatly distended with urine, there had been no leakage through the prostatic urethra. In this case an anastomosis between the prostate and membranous urethra was easily accomplished and no stricture followed the healing of the wound, but the patient never had erections of the penis afterward.

One finds numerous reports of injuries to the prostate in time of war from bullets, spears, sabres, etc. Such injuries have also been produced by falling astride sharp objects. The symptoms and treatment are evident.

False routes of the prostate are the result of the passage of instruments. Owing to the sharp curve taken by the urethra at the triangular ligament, and to certain anatomic irregularities in the prostatic urethra,—verumontanum, utricle, ejaculatory ducts, prostatic sinuses, and uvula vesicæ,—some traumatism may occur in even normal cases, especially if instruments of small size and with sharp points are used. On account of its superior ability to enter the membranous urethra from the bulb and to ride over the verumontanum and the uvula vesicæ, the flexible gum coudé catheter (of Porgés make, which can be boiled) is the instrument of choice for catheterization, even in normal cases. A rubber Nélaton catheter frequently catches in the bulb of the urethra, in front of the spasmodically closed external or vesical sphincters, and a metal catheter should always be used with great care, owing to the greater danger of traumatism.

The marked alterations in the urethra and prostate produced by pathologic processes often render it very difficult to insert any instrument, and false passages have been of frequent occurrence. In the Museum of the Royal College of Surgeons, London, one may see many striking examples of this character, not only false routes through enlarged middle or lateral lobes, but also through the urethra at the site of strictures.

Albarran recognizes three degrees: Rupture of the urethral wall alone; incomplete false route extending into the prostatic tissues; complete false route or tunnel into the bladder.

These are merely variations in the degree of the injury produced and the symptoms which accompany them are very variable. In some cases very little trouble is produced, but in many cases hemorrhage, severe prostatic or periprostatic infections, suppurations, and sepsis result.

The **diagnosis** should be made at the occurrence of the injury, but, as a matter of fact, if the proper instruments were selected, care exercised, and particularly if all forceful efforts were avoided, false passages would practically never occur. The production of considerable hemorrhage and the inability to withdraw urine when the catheter has apparently entered the bladder should make one suspect a false passage at once. The inability to turn a metal instrument generally indicates that its point is not free in the bladder cavity.

The **treatment** is both prophylactic and curative. As remarked above, if one has the proper instruments, avoids unyielding and sharp-pointed catheters and sounds, and is careful not to use force, false passages should never occur either in stricture or prostatic hypertrophy. Curative treatment is generally not necessary, as the injury often heals rapidly if it is not repeated. In some cases it may be advisable to make use of a *catheter à démeure* for a protracted period, and sometimes perineal or suprapubic drainage is advisable. In case of severe infection, abscess formation, urinary infiltration, etc., the appropriate operative measures should be taken.

Recto-urethral fistulas should be included here, as they are almost always the result of injury of the rectum during perineal operation upon

the prostate and bladder. In most cases there is a communication between the middle of the prostatic urethra and the rectum, through which urine escapes into the rectum or feces into the urethra. As mentioned elsewhere, the anterior surface of the rectum is in close proximity to the membranous urethra and prostate, being held there by the recto-urethralis muscle, and in operations through the perineum, unless this muscle and the posterior layer of the fascia of Denonvilliers are divided and the rectum carefully pushed back, it is quite likely to be injured. If in closing the wound the rectum is left unprotected and unsupported by the failure of the operator to approximate the separated levator ani muscles, necrosis may result. In both cases a rectal urethral fistula is apt to occur.

A recto-urethral fistula is often not only one of the most uncomfortable conditions, but also one of the most difficult to cure. This is due to the fact that the wound is very apt to break down after plastic operations for its closure. Various methods have been advocated, one being that of Tuttle, a plastic closure of the urethral and rectal openings separately, with drainage of the bladder through a retained urethral catheter. This method was always unsuccessful in my hands until I added to it suprapubic drainage, thus doing away with the retained urethral catheter, and the spasmodic efforts of urination which occurred after its removal. Since adopting this method I have had no difficulty in effectually curing recto-urethral fistulas which had previously resisted all efforts to cure them without suprapubic drainage.

Prostatic Calculi.—Prostatic calculi may be divided into two groups, on account of their origin and location: (1) Calculi which lodge in the prostatic urethra, having escaped from the kidney, bladder, or seminal vesicles, and the small group of cases in which the stone is primarily formed in the posterior urethra. (2) Calculi which are formed in the substance of the prostate gland—the true prostatic calculi. This second group is entirely distinct in origin and nature from the urinary calculi.

On account of the intimate relation existing between corpora amylacea and prostatic calculi, it is necessary to consider the former before taking up the subject of true prostatic stones.

Corpora amylacea ("corpora amyloidea," "corpora colloidea," "prostatic concretions") are found in various organs of the body. Since Morgagni described and likened them to tobacco seeds in 1723, they have been studied and variously described by numerous investigators. Thompson says they are always present after the twentieth year, but he also found them in the prostate of a child. In late life they are more numerous and larger than in young men, and in prostatic hypertrophy they are especially numerous. These amylaceous bodies may be single or multiple and scattered throughout the gland, but chiefly in the ducts about the verumontanum. In one prostate which Thompson dissected he estimated that several thousand of these bodies, visible to the naked eye, were present. Their size is microscopic, as a rule, and their form round, oval, or, when compressed, angular; their outlines are well defined; in color they vary from light to dark yellow, growing darker with age and size. The central part, or nucleus, looks like a fused mass of cells and is sur-

rounded by an outer laminated substance with radiate striations. On section small corpora amylacea seem to be homogeneous; the larger show the laminated structure more distinctly and resemble small uric acid calculi somewhat; hence probably arose the idea that these bodies were of urinary origin.

Ziegler says the process is entirely dependent upon a local condition, being in part a degeneration of the epithelial and in part a degeneration of the connective-tissue cells. Quekett thought there was a deposition of earthy matter in the secreting cells of the gland; Mercier, a stagnation of the prostatic secretion and separation of calcium salts; Virchow, the separation of an albuminous body about the amyloid degenerated cells as a nucleus. Siegert: (*a*) those which give the iodid reaction and never calcify are probably due to a stagnation of the gland fluid; (*b*) those which never give the iodin reaction are due to calcified glandular epithelium. Posner classes the concretions as calculi and considered lecithin an essential constituent. Englisch shares Posner's view that the amyloid bodies are true stones, and mentions as a final cause of their formation the possibility of a microbic invasion of the gland. The small bodies are mostly organic (in fact, those microscopic in size may be entirely so) and the larger bodies are chiefly inorganic.

According to Thompson, corpora amylacea, having attained the size of their inclosing follicle, act as foreign bodies, and in consequence of the general law that all mucous membranes when sufficiently irritated throw out a deposit of calcium phosphate and carbonate, ultimately form calculi. The amount of earthy matter varies from 45 per cent. in the concretion to 85 per cent. in the calculus.

There have been eleven cases of prostatic calculi in my practice. In eight cases they were found embedded in the prostatic tissue and removed with enlarged prostates. Their size was variable, but generally about the size of a millet-seed. In most cases they were scattered irregularly throughout the lateral lobes, but in one case they were only found in the periphery beneath the capsule, and in another case only in the median lobe. In none of these cases was there a history suggesting renal lithiasis, and only three were associated with vesical calculi. In two cases the calculi lay partly in the urethra and partly in the prostate.

The prostate was only slightly enlarged in most cases and a marked prostatitis was generally present. In one case, a child four years of age, a calculus 1.5 cm. in diameter was removed from the left lobe of the prostate through a perineal incision. In another case, a patient aged thirty-six years, three calculi almost completely filled the prostatic capsule, the gland tissue being greatly compressed and thinned. Another case was found at autopsy and showed multiple seed calculi in the substance of the prostate associated with prostatitis. The other eight cases were in elderly men suffering with prostatic obstruction. In these the presence of calculi did not at all complicate the operation of perineal prostatectomy.

The number of calculi present may vary from one to several hundred. They are generally a little less than that of a barley-seed in diameter, but they may range in size from 2 mm. to 3 or 4 cm.

As a rule, these stones have a smoother surface than urinary calculi, but occasionally chemical analysis is necessary in order to distinguish one from the other. The lamellæ are of irregular thickness and between them organic matter may be found. The individual lamellæ may give different reactions and vary in hardness. When the stones are small and numerous, the gland on section has a somewhat sieve-like appearance; frequently there is an associated glandular hypertrophy and periacinous round-cell infiltration. The epithelium lining the sac may have entirely disappeared, and in some instances pressure atrophy causes a disappearance of the entire gland with the exception of its capsule.

Symptoms.—The evolution of the clinical symptoms in cases of prostatic calculi is slow, as a rule, depending in a large degree upon the location, the size, and the number of stones. At times the symptoms may be masked by complications, such as renal or vesical calculus, prostatic hypertrophy, or urethral stricture. Stones deeply embedded in the gland cause, as a rule, but slight disturbance, and the gland may be filled with stones and yet no marked symptoms occur. Irritability of the bladder and pain are sometimes present; the latter may be little more pronounced than a sensation of weight and fullness in the perineum and associated only with urination or defecation. Frequency or hesitancy of urination is seen oftener than initial or terminal hematuria, the latter being much more constant and characteristic in the case of vesical stone. Retention or incontinence occurs especially if stones are located in the middle lobe. Pyuria is seen in those cases in which there is a communication existing with the urethra. Occasionally the genital symptoms assume marked prominence; testicular pain, frequent ejaculations, feeble erections, and a condition of semi-priapism having been noted in different cases. Frequency or hesitancy, and slight perineal or suprapubic pain, are usually the group of symptoms of which the patient complains. Englisch calls attention to the fact that the paucity of symptoms is in striking contrast to the wide extent of the disease in the gland, and hence the great importance of the physical examination. Rectal palpation in the early stages may disclose an enlarged but not indurated gland. When the calculi are not near the posterior surface, the gland is smooth and regular; as the stones approach the periphery it becomes irregular and the hardness may be very marked. The sac containing the stone often has more or less mucus in it, and by firm pressure the latter may be displaced and the hard body beneath noted. When two or more stones are in contact, crepitus may be elicited. It may be absent, however, even when a great many stones are present. Stones in the middle lobe cannot be felt by rectal palpation. When the stone is in communication with the urethra, a sound will give crepitus, and considerable additional advantage is obtained by the simultaneous rectal palpation with the finger. If a rectal or perineal fistula exists, the passage of a probe through it frequently leads to the stone. With the cystoscope or the urethroscope the calculus can sometimes be seen and the *x*-ray has been used with considerable advantage.

Diagnosis.—In making a diagnosis the following possibilities, which

may give similar symptoms or signs, must be considered: prostatic phleboliths, urethral (prostatic) calculi, calculi of the seminal vesicles projecting into the urethra, urethral incrustations, prostatic hypertrophy, cancer, and tuberculosis and renal or vesical calculi.

The **complications** occasioned by prostatic stone are, briefly: abscess, fistula, prostatic hypertrophy, incontinence or retention of urine, sexual disorders, including deferentitis and epididymitis. Before undertaking the operative treatment of these cases, the presence or absence of the following conditions should be determined, if possible: urethral stricture, prostatic hypertrophy, renal or vesical calculi.

Treatment.—Sir Benjamin Brodie, Liston, and other surgeons removed prostatic calculi through the urethra by means of forceps and scoop, but these methods have been abandoned. When the stone communicates with the prostatic urethra, it may be removed through the bladder by suprapubic cystotomy. In cases where the stone is more or less completely embedded in the prostatic substance the suprapubic route is contraindicated. As a matter of fact, the perineal route is preferable in most cases. The prostate should be exposed as for a perineal prostatectomy, and opened either upon a grooved staff or upon a prostatic tractor which has previously been inserted. In young patients the calculi are usually not great in number and it is not necessary to remove gland tissue. The multiple seed calculi which are found scattered throughout the gland are almost always associated with prostatic hypertrophy or obstructive prostatitis, and prostatectomy is indicated, being the simplest way of removing the calculi. The operative procedures have been discussed at length in vols. xiii and xiv of the "Johns Hopkins Hospital Reports."

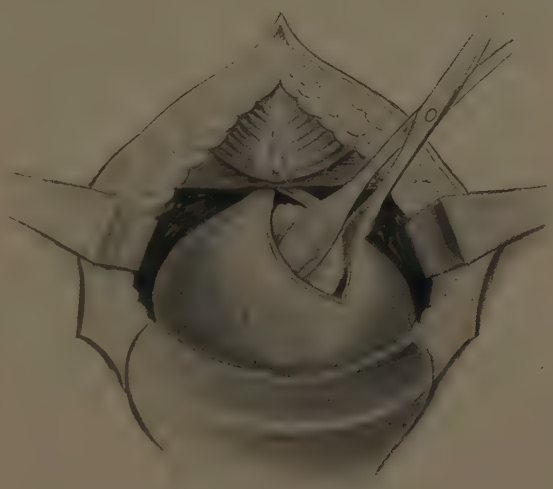

FIG. 210.—REMOVAL OF CALCULUS.

Acute Prostatitis.—Acute prostatitis has been classified by Albarran as follows:

I. Glandular.

II. Parenchymatous.
- Non-suppurative.
- Abscess.
- Periprostatic phlegmon.

By glandular prostatitis is meant inflammation of the prostate which involves only the glands themselves and in which the periglandular tissue does not take part in the inflammatory process. In the parenchymatous form both glandular and interstitial tissue is involved.

Glandular Prostatitis.—This is taken to mean the simplest form of acute prostatitis, in which there is merely a proliferation of epithelium with desquamation and marked diapedesis. In most cases it is due to an invasion of the gonococcus into the depths of the prostatic gland. In mild cases only that portion of the prostate immediately around the urethra is involved. In more advanced cases the larger part of the prostate may be involved, but in some cases very little swelling of the prostate and few symptoms are produced. Goldberg has employed the name of "prostatitis endoglandularis," and as there is considerable objection to the word catarrhal, this would seem the better name to adopt.

The *symptomatology* of this form of prostatitis is that of acute posterior urethritis, with which it is almost always associated. The urine is usually cloudy in all three glasses, and there is frequently more pus in the last glass and occasionally a slight amount of blood. At times marked frequency of urination and strangury are present, and in rare instances definite obstruction to urination, occasionally complete in character. The diagnosis is based upon the presence of acute posterior urethritis and of a swollen tender prostate on rectal examination.

The *treatment* consists in the use of diuretics and balsamics internally, hot or cold rectal lavage through a two-way rectal tube, suppositories of opium and belladonna in case of pain, and, later, intravesical irrigations of mild solutions of potassium permanganate or bichlorid of mercury (1:60,000) forced in by hydraulic pressure without the use of a catheter. When all acute symptoms have subsided, the use of prostatic massage, irrigations, dilatations, and the deposition of ointment may be necessary.

Parenchymatous Prostatitis.—As mentioned above, this term is used to define the more severe forms of inflammation, which involve both the glandular and interstitial substances of the tissues of the prostate, and it seems probable that most cases are of this type, though the extent of the invasion and inflammation is often very variable.

Pathology.—The prostate is generally enlarged, and on cross-section appears to contain numerous small abscesses, but Thompson, Finger, and others have shown that the walls of these small purulent collections are formed by epithelium, and that the condition is a follicular prostatitis with retention. In later stages definite abscess formation occurs, partly by the breaking down of the retention cysts above described and purulent foci in the interstitial tissue. Lallemand counted as many as thirty small miliary abscesses in one case. The abscess cavities are often very irregular with fibrous septa dividing them as partitions. In rare cases the abscess completely surrounds the urethra without perforating its walls, and in one such case in my practice after opening the abscess through the perineum the urethra was found intact. The ejaculatory ducts, seminal vesicles, and ampullæ of the vasa deferentia are very frequently

simultaneously involved, often forming large retrovesical abscesses. In eighty-eight cases of acute prostatitis Colombini found forty-eight cases of vesiculitis. The progress of the abscess is generally toward resolution, but there is not infrequently a rupture into the urethra, the evacuation leading to fairly rapid cure. The direction most commonly taken is toward the rectum; in other cases toward the perineum. In very rare instances it may rupture into the peritoneal cavity. In some cases the pus has burrowed between the peritoneum and the side of the bladder, and finally found its way into the inguinal canal, the obturator canal, or toward the umbilicus. Occasionally both rectum and urethra break down, leading to recto-urethral fistula.

Etiology.—The following table of Segond shows at a glance the pathogenesis:

Prostatic Infections.

- **Exciting causes.** — **Pathogenic bacteria.**
  - Gonococcus.
  - Staphylococcus.
  - Streptococcus.
  - Colon bacillus.
  - Pneumococcus.
  - Anaërobics.

  → **Avenues of Infection.**
  - I. *Ascending.* Acute posterior urethritis. Gonorrheal or non-gonorrheal. Catheterization, etc.
  - II. *Circulatory.* With the acute exanthemata, typhoid fever, etc.
  - III. *Lymphatic.* Proctitis, periproctitis, hemorrhoids, perirectal fistulas, pericystitis.
  - IV. *Direct infections.* Traumatisms from without and within, injuries, false passages, calculi.
- **Predisposing causes.** — Adult age. Cold. Contusions (falls, riding, bicycling). Marching. Constipation. Superpurgation. Hemorrhoids. Sedentary habits. Excess of coitus. Masturbation. Balsamics.

The above table is so complete that it hardly needs further discussion. It may be said, however, that the great majority are due to gonorrheal infections, and are of an ascending nature, but cases occurring with rectal diseases and the acute infectious fevers are not uncommon. The gonorrheal infections do not, as a rule, go on to extensive abscess formation.

Complications.—Besides the periprostatic infections mentioned above, various urethral, vesical, renal, and general complications occur: viz.,

ascending infection of bladder, urethra, and kidneys, retention of urine, uremia, septicemia, etc.

Symptoms.—The symptoms of prostatitis are very variable. Often with considerable involvement there may be very few symptoms present, but in most cases there is fever, and pain in the perineum and rectum, which is worse during urination and defecation. Difficulty and frequency of urination and sometimes strangury are present.

The *diagnosis* is based on rectal examination, which usually shows at once a tumefied prostate, which is hot and tender, and often associated with enlargement of the seminal vesicles and periprostatic structures. Instrumental examination of the urethra should usually not be made, and in fact the rectal examination should be very carefully done so as to avoid injury.

Treatment.—The therapeutic indications in acute prostatitis depend upon the extent of the disease. In cases where there is no obstruction to urination and definite abscess formation has not occurred an expectant treatment is generally preferred. Rest in bed, diuretics, and hot or cold rectal irrigations are the methods usually employed. When a definite abscess is present, it may be treated expectantly or by operation. The urethral route, which is the most common natural method for the evacuation of the abscess, was employed by Velpeau, who constructed a special instrument with which the urethra was perforated and the abscess evacuated. A modification of this method consists in a perineal urethrotomy and the evacuation of the abscess through the urethra, which is opened by means of the finger. This method has been successfully employed by Alexander. Another method through the perineum consists in avoiding the urethra and cutting directly down upon the purulent collection. In this way it may be possible, as in one of my cases, to evacuate the prostatic abscess without opening the urethra, thus avoiding perineal urinary fistula. If the abscess points immediately beneath the skin, this is easy of accomplishment. Where the abscess is deeply seated, it may be exposed by a median perineal urethrotomy or by means of an operation somewhat similar to the one which I have advocated for prostatic hypertrophy, the apex of the prostate being exposed through an inverted V cutaneous incision. Great care must be taken to avoid injury of the rectum. Where the inflammation involves the seminal vesicles more extensively than the prostate, it may be advisable to expose and incise the posterior surface of the seminal vesicles. After evacuating the abscess and packing the cavity with gauze the levator ani muscles should be carefully approximated so as to prevent pressure necrosis of the rectum. As a rule, however, the abscess presents so close to the perineum that the operation is simple. The rectal route has been utilized both for evacuation through a cannula and incision and drainage. Most authors are, however, opposed to the intrarectal route, owing to the inefficient drainage procured and the fear of recto-urethral fistula. Very extensive acute prostatitis with abscess formation and vesiculitis sometimes resolves without operative treatment, and it is therefore best to employ the simpler methods first.

If retention of urine occurs, the application of heat to the lower abdomen and perineum, hot enemata, sitz-baths, and morphin should be tried. If these measures fail, a soft-rubber Nélaton catheter should be introduced, but if it cannot be passed suprapubic aspiration of the bladder with a small needle is preferable to prolonged instrumentation. In the presence of severe acute anterior urethritis catheterization is inadvisable and suprapubic aspiration to be preferred. As a rule, only one aspiration of the bladder is necessary, since the congestion generally diminishes sufficiently to allow the patient to void urine naturally. Aspiration may be repeated a number of times if care is taken and a new site for puncture chosen each time.

Chronic Prostatitis.—Chronic prostatitis, which is one of the most frequent of diseases, has not received much attention until recent years, and even now its great importance as a causative factor in the production of various painful maladies and neuroses is not generally appreciated. As a result of the reports of many workers, prominent among whom may be mentioned Thompson, Finger, Guyon, Albarran, and Oberländer, our knowledge of this affection has been much increased.

Etiology.—In an analytical study of three hundred and fifty-eight cases reported last year from my practice there was a history of gonorrhea in 73 per cent.; of marked habit of masturbation in 7 per cent.; of frequent prolonged sexual excitements (without coitus) in 2 per cent.; of descending infection in 0.8 per cent.; traumatism, bicycling, etc., in 0.8 per cent.; instrumentation, 0.6 per cent.; infectious diseases, 0.3 per cent. No etiology was obtained in fifty-three cases. The age at which the symptoms appeared was under forty years in 65 per cent. of the cases; twenty-three patients were between forty and fifty years of age, and twelve over fifty years of age. In most cases it was impossible to get a history dating back to an attack of severe acute prostatitis, and generally the disease seems to have come on insidiously, the first symptoms appearing a long time after the original attack of gonorrhea.

Bierhoff reported finding the gonococcus in fifty-seven out of sixty-two cases, but Notthaft, in a very careful study of one hundred and twenty cases of chronic prostatitis, found as follows: in forty-two cases examined within one year after the infection, the gonococcus alone was present in only four (0.9 per cent.); in twenty-four cases examined between twelve and eighteen months after infection, only in one case (4 per cent.). The gonococcus was present either alone or with other bacteria in 73 per cent. of the patients seen within six to twelve months after the last infection; in 50 per cent. of those within twelve to eighteen months; in 18 per cent. of those seen within eighteen to twenty-four months; in 6 per cent. of those seen within twenty-four to thirty-six months. No gonococci were found in the secretion after the third year. Summing up the whole work, Notthaft found in one hundred and twenty cases the gonococcus forty-seven times, other micrococci nineteen times, bacilli fifteen times, and other bacteria fourteen times. In twenty-six cases in which cultures were taken by us after very careful efforts had been made to sterilize the penis and urethra, we were able to obtain positive bacterial growths in

only eight cases. In three of these the organism was the staphylococcus albus; in two a slender bacillus which could not be identified and in two a streptococcus. The gonococcus was not obtained once.

The results of a study of many smears made from prostatic secretion show that only in a small proportion of cases could bacteria be found in the purulent secretion obtained from the prostate by massage. The frequency and longevity of the gonococcus is still an unsettled question and much careful work is needed. The present literature is inaccurate owing to the careless methods pursued.

Pathology.—Chronic prostatitis is usually said to be of two varieties: the follicular and the interstitial, but in a study of fourteen cases in which autopsies were obtained we were unable to justify this classification. In no instances was the inflammatory process limited to the parenchyma, and the periacinous infiltration was so generally present that it seemed to be the essential lesion of chronic prostatitis. The changes in the acini are many; in some cases they are dilated and filled with inflammatory products, in others they are contracted and even replaced by fibrous tissue. Not infrequently groups of acini are seen in which the inflammation has subsided and the epithelium was healthy. In five cases of prostatitis in which the obstruction to urination was present (for which perineal prostatectomy was performed) careful examinations of the enucleated lobes showed none of the spheroids seen in hypertrophy, but a firm homogeneous character. The glandular tissue in the median portion of the prostate was distinctly increased in amount, forming a definite bar, but microscopic sections showed the lesions seen in ordinary prostatitis with some glandular proliferation.

In only six of the fourteen autopsy cases was there any evidence of chronic seminal vesiculitis and in only one of these was it active in character. There was considerable fibrous hyperplasia around the vesicles, which involved the mucosa and submucosa, but the epithelium was normal in all but one case.

Changes in the Prostatic Secretion.—The secretion of the prostate and seminal vesicles may be obtained by rectal massage. This is best performed with the patient bending forward with his elbows upon his knees. The operator inserts his index-finger, covered with a finger-cot, into the rectum and makes firm pressure, generally beginning at one vesicle and gradually descending upon the surface of the prostate. In this way both of the seminal vesicles and the prostatic lobes can be "stripped." A similar process along the urethra in the median line will force the fluid forward through the membranous urethra, and it will generally appear at the external meatus, having been carried there by gravity alone. Occasionally it may be necessary to make pressure upon the bulbous urethra in order to obtain secretion at the meatus. Microscopically prostatic secretion consists largely of lecithin bodies with a few epithelial cells and occasionally corpora amylacea. A variable number of spermatozoa and large mucin-like globules may be present, both coming from the vasa deferentia and the seminal vesicles. The lecithin bodies are not of uniform size, some being very small and the largest about the size of a

red blood-corpuscle. In normal prostatic secretion leukocytes are not present except in small number.

In the secretion obtained by prostatic massage, in cases of chronic prostatitis, pus is nearly always present in greater or less amount, and the proportion of normal elements present varies inversely with the pus found. In two hundred and eighty-nine cases of chronic prostatitis we have found pus present in all cases after the second or third examination, and often in such large amount as to more or less completely obscure all normal elements. Other observers have noted the fact that the first expression of prostatic secretion does not usually show the true proportion of pus cells, and only after several examinations are they present, in certain cases, although rectal examination may show marked evidence of chronic prostatic inflammation. This is possibly due to the fact that some of the acini, probably those nearest the urethra, are in a more healthy condition than the peripheral acini, the secretion of which is more difficult to empty into the urethra. We have found no cells characteristic of chronic prostatitis other than leukocytes, which in stained specimens have been found to be largely neutrophilic, though a few cells with eosinophilic granules were seen. In a few cases large compound granule cells have been very abundant. These have generally been in men past middle age. Corpora amylacea are occasionally seen in marked excess, but in only rare instances. The presence of motile spermatozoa seems to depend very little upon the character of the prostatic inflammation. In many cases in which the secretion was almost entirely composed of pus, actively motile spermatozoa were seen, and the pus present does not seem to produce non-motility of the spermatozoa, as one would expect in view of Fürbringer's assertion that prostatic secretion was necessary to produce motility of the spermatozoa. We have been surprised to find often that those cases giving a gonorrheal history were not characterized by the presence of more pus in the prostatic secretion than those in whom gonorrhea had apparently not been present. The amount of pus present is generally in direct proportion to the severity of prostatic involvement shown by rectal examination, but in a fairly large proportion of cases in which the rectal examination showed only slight changes the prostatic secretion showed a large amount of pus, and in about 5 per cent. of the cases the presence of chronic prostatitis would have been overlooked had rectal examination alone been made.

The reaction tested with litmus was always alkaline. Our investigations showed that stained preparations were of very little assistance except in determining the presence of bacteria, which were present in a very small proportion of cases. Unless very careful precautions are taken to render the penis and urethra clean, one cannot be positive that the bacteria seen in the secretion obtained at the meatus come from the prostate.

Symptoms.—The usual text-book description of the symptoms of chronic prostatitis gives but a meager idea of the manifold phases which they may assume. The influence of the prostate in perpetuating and rekindling inflammation of the urethra is quite well recognized, but its rôle

in producing symptoms apparently in no way connected with the gland, and in simulating other affections, is not well appreciated. Of three hundred and fifty-eight cases, two hundred and ninety-six had symptoms other than urethritis, and in only sixty-two was there simply a complaint of urethral discharge or shreds in the urine.

The symptoms of chronic prostatitis may be classed in three subdivisions; viz., sexual, urinary, and referred.

The sexual symptoms form a very important group, and frequently constitute the only reason of the patients applying for treatment. In our series of cases the following sexual complaints were noted: Premature ejaculation, 64; prostatorrhea, 41; imperfect or absence of erections, 38; diminished vigor, 33; frequent nocturnal emissions, 31; sexual hypersensitiveness, 7; painful ejaculation, 7. In the cases of prostatitis resulting from masturbation and frequent sexual excitement without gratification, prostatorrhea, nocturnal emissions, and precocious ejaculations were very common complaints, but the same symptoms were present in less number as a result of gonorrhea.

Prostatorrhea may be produced by the acts of urination or defecation, and sometimes merely as a result of slight sexual excitement or even sensuous thoughts, and its differentiation from spermatorrhea, which may occur under similar conditions, is made by the presence of prostatic cells in the former and spermatozoa alone in the latter. In some cases sexual hypersensitiveness is very marked, and occasionally causes much mental depression.

In ten cases the chief complaint was sterility, and repeated examinations failed to show actively motile spermatozoa, and in some cases they were entirely absent.

The urinary symptoms are often very mild, a mere discomfort or burning in the urethra. In other cases, however, these symptoms cause great distress. In our cases they were classified as follows: Frequency of urination, 90 cases; pain during urination, 46; urgency of urination, 25; slow or difficult urination, 11; irritability of the deep urethra, 11; pain at the end of urination, 7; pain at the beginning of urination, 3; dribbling after urination, 1.

In thirty-four cases in which a definite obstructive prostatitis was present the symptoms were very varied. In a few cases there was only a slight hesitation at the beginning of urination, but in others urination was quite difficult and occasionally very frequent. In two cases only was the retention of urine complete, but both of these were young men thirty-two and thirty-seven years of age, and one had used the catheter for twelve years. A sharp pain at the end of urination, referred to the glans penis, is not uncommonly present, and the occasional presence of terminal hematuria makes the simulation of vesical calculus very close.

The referred symptoms of chronic prostatitis are generally of a painful nature, and involve the back, hips, thighs, rectum, perineum, scrotum, and groins most commonly. In our cases the location of these referred pains was as follows: In the lower lumbar region, 64; in the region of the kidney, 8; of a colicky nature simulating renal colic, 10;

in the perineum, 35; suprapubic, 22; groin, 18; testicles, 18; urethra, 14; rectum, 13; thighs, 12; hips, 10; sacrum, 5; simulating sciatica, 5; knees, 4; legs, 4.

These referred pains are often of a dull aching character and come on intermittently. In some cases painful seizures of considerable intensity occur. This is particularly true in those cases which simulate renal colic, the attacks being of such great severity as to require morphin and rest in bed for a protracted period. These attacks are not infrequently accompanied by hematuria and marked irritability of the bladder, so that the simulation of renal colic due to calculus is often perfect, and in six of my ten cases exploratory operation had been performed upon the kidney without finding a calculus. Rectal examination in these cases usually showed a very marked prostatitis with considerable infiltration in and around the seminal vesicle and adhesions to the pelvic wall on the affected side. The rectal symptoms are often very distressing and characterized by burning, marked irritation, sensation of fullness, etc. The scrotal, testicular, and inguinal symptoms are also very distressing at times, and in a number of instances the patient had been subjected to operation for varicocele without relief. Pain in the back is the most common symptom and is often very severe in the morning. It is very similar in character to that experienced by women with pelvic inflammatory disease. According to Head, a painful stimulus to an internal organ is conducted to that segment of the cord from which its sensory nerves are given off. There it comes into close connection with the fibers from the surface of the body which arise from the same segment, and thus by psychic error the pain is referred to another region than that of the viscera actually affected. The prostate receives fibers from the tenth, eleventh, and twelfth dorsal, the first, second, and third sacral, and the fifth lumbar segment. It is therefore easy to understand how the distribution of referred pains in diseases of the prostate may be very varied, and involve, as we have shown, all regions from the diaphragm to the feet.

Diagnosis.—A slight watery urethral discharge, pain in the back and legs, testicular pain, perineal discomfort, intermittent frequency of urination, weakened sexual vigor, premature ejaculations, frequent nocturnal pollutions—the presence of any of these symptoms should initiate a most careful examination of the prostate. The rarer symptoms, notably renal colic, sciatica, pains in the groin and scrotum, which have been discussed in an earlier section, must also be borne in mind.

In all cases the absolute diagnosis depends on rectal palpation, massage, and microscopic examination of the prostatic secretion. In three hundred and fifty-eight of our cases, some enlargement of the prostate was noted in two hundred and twenty-seven, no enlargement in forty-two, induration in two hundred and eighty, no induration in thirty-three, tenderness in fifty, irregular or nodular surface in fifty-six, a smooth surface in twenty-nine. The whole prostate was affected in a hundred and fifteen, the upper pole only thirty-six, the periphery alone

thirteen, only one lobe twelve times. Changes were noted in the seminal vesicles in one hundred and forty-three cases, in fifty-eight of which only the lower ends were involved; one vesicle only was involved in forty cases. Periprostatic and perivesicular adhesions were very commonly present, extending upward and outward through the lateral wall of the pelvis, and forming in some instances an extensive mass of induration as high as the reach of the finger. In most cases, however, the adhesions were of moderate degree. Infiltration along the vasa deferentia and the intervening space on the posterior wall of the bladder was comparatively rare, but in a few instances a broad plateau of induration was present above the prostate in the median line. The induration present in chronic prostatitis is generally not uniform and not of stony hardness, as in the case of carcinoma. Occasionally a very hard mass may be present, but it is generally smooth, localized to one portion of the prostate, and does not extend beyond the limits of the capsule.

Microscopic study of secretion obtained by massage (which generally flows to the meatus unassisted) is of very great importance, as certain cases of prostatitis show no palpable change on rectal examination and would be overlooked but for the finding of pus in the prostatic secretion.

A perusal of the symptomatology of chronic prostatitis shows at once that many conditions are simulated by this most prevalent and often overlooked malady. Renal colic, vesical calculus, chronic cystitis, hemorrhoids, carcinoma of the rectum, sciatica, rheumatism, arthritis, hernia, epididymitis, disorders of the abdominal viscera, general neurasthenia and hypertrophy, cancer and tuberculosis of the prostate—any of these one may be called upon to differentiate from chronic prostatitis.

It is impossible, therefore, for us to discuss in full the diagnosis of chronic prostatitis. We must insist, however, upon the great importance of rectal examination of the prostate and microscopic examination of its expressed secretion as a routine in physical examination. If this were done, many a poor individual who has continued to suffer while stigmatised a neurasthenic would find relief, many a case of supposed rheumatism, sciatica, lumbago, and renal colic would be correctly diagnosed and cured.

In tuberculosis of the prostate other evidences of tuberculosis are generally found, lesions in the epididymis or kidneys or more remote organs, painful, frequent, and difficult urination, often associated with hematuria, are more commonly present, and the rectal examination shows greater irregularity, greater tenderness, areas of caseous softening interspersed between areas of marked induration, and considerable periprostatic and perivesicular infiltration. Extension of the disease to the urethra, perineum, pelvic glands, and rectum is also not uncommon. In mild cases, however, the differential diagnosis may be difficult, and the administration of tuberculin necessary owing to the presence in the urethra of the smegma bacillus, which has the same tinctorial characteristics as the tubercle bacillus. Investigations which were conducted by Churchman and me have shown that if the penis and urethra be thoroughly cleansed,

the smegma bacillus will not be found in the voided urine or prostatic secretion.

Prostatic hypertrophy can generally be recognized by globular enlargement or rectal examination, but in some cases no enlargement is to be made out except with the cystoscope, when the characteristic median or lateral intravesical outgrowths will be seen. The presence of residual urine, vesical trabeculation, pouch formation, and contracture or dilatation of the bladder are also of assistance in showing obstruction to urination. In some cases of chronic prostatitis a definite median bar is present and is accompanied by both residual urine and trabeculation of the bladder. The cystoscope is often useful by showing hyperemic or granular condition of the trigone and vesical margin, and thus explaining the cause of irritability and frequency of urination, and the urethroscope should be used to see the condition of the prostatic urethra, the verumontanum, and thus the cause of irritability and sexual disturbances in that region. Considerable congestion is thus often discovered and an enlarged hyperemic verumontanum not infrequently found. Such conditions, however, are often present with simple prostatorrhea and spermatorrhea, but the presence of pus in the prostatic secretion will determine at once whether the disease is of an inflammatory character. Careful rectal and microscopic examinations have reduced very greatly in number the cases of true spermatorrhea.

The value of the three-glass test in determining chronic prostatitis is apparently a minor one. The comma shreds only give positive information of infection in the ducts and not of the extent of the prostatic involvement. In only thirty-two of our cases was it possible to determine the presence of shreds from the prostatic ducts in the third glass, but in many of the cases all three glasses contained shreds, some of which undoubtedly came from the prostate.

Complications.—In our three hundred and fifty-eight cases chronic urethritis was present in one hundred and ninety-six; seventy-eight of these had a urethral discharge, and one hundred and eighteen had shreds in the urine but no discharge. In eighty-four cases no urethritis was present. In forty-three cases the presence of urethral shreds was obscured by pyuria due to cystitis. In two hundred and eighty cases which were very carefully examined, in eighty-four, or 30 per cent., the prostatitis was not accompanied by urethritis. Stricture of the urethra was present in twenty-six cases, but those of very wide caliber and slight degree were not counted. The cause of the vesical infection, which was present in forty-three cases, was often due to previous uncleanly instrumentation, but a number of cases were seen in which the bladder had never been instrumented, and the infection had probably come from the prostate. Twenty cases developed bacteriuria during treatment (almost always following prostatic massage), the infection evidently coming from the secretion which flowed back into the bladder. The infection was generally due to a bacillus of the colon group. In a number of cases the prostatitis was due to masturbation. In four cases chronic prostatitis was secondary to pyonephrosis or pyelitis, and

in numerous other cases which were not tabulated it was evident that the prostate had become infected from bacteria which came down from the kidney or bladder. This was not infrequently seen as a result of fever, such as typhoid.

Prognosis.—The course of chronic prostatitis is not usually toward spontaneous cure, and the frequent development of recurrent urethritis, epididymitis, marked sexual disturbances, referred pains and neuralgias in various portions of the body shows the great importance of early diagnosis and treatment. A continuation of the disease often produces neurasthenics of a most distressing and despondent type, and I have known several to commit suicide. It therefore seems important to urge again the routine examination of the prostate. The prognosis under treatment is excellent.

Treatment.—More effective than anything else is systematic *prostatic massage.* The object of this is to squeeze out as much as possible of the purulent contents of the prostate, to soften areas of induration, periprostatic infiltration, and adhesions. The technic followed may be briefly described as follows: The patient, having voided his urine, bends forward with elbows upon his knees and the operator inserts a gloved forefinger into the rectum. The massage is begun generally high

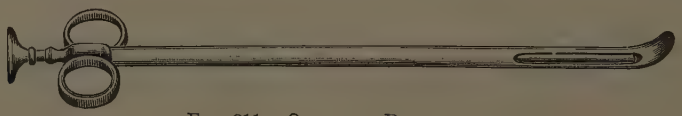

Fig. 211.—Ointment Depositor.

up on one side over the seminal vesicle; considerable pressure is exerted with the finger, which is gradually drawn downward, thus traversing the seminal vesicle and the corresponding lobe of the prostate. The maneuver is then repeated on the opposite side, and lastly in the median line. The procedure is continued for a period of two or three minutes, all portions of the prostate and vesicles being thoroughly massaged several times, but special attention being given to the more pathologic portions. Areas of marked induration often yield best to steady, firm pressure, and in this way one avoids too much traumatism to the rectal mucosa. After the massage has been finished the urethra and bladder should be irrigated with some antiseptic solution (I generally use 1 : 60,000 bichlorid of mercury) in order to prevent urethral and vesical infection from the purulent secretion squeezed from the prostate. Hydraulic pressure should be used, as it is much simpler than the use of a catheter for lavage. After the patient has voided the irrigating fluid, I usually make a deposit of 2 per cent. carbolic lanolin ointment into the posterior urethra. This penetrates very deeply into the gland, especially after massage, and I believe is of considerable value. The ointment depositor shown in Fig. 211 has proved very satisfactory.

The use of high dilations of the posterior urethra is also of considerable service, and for this purpose the Kollmann dilator is of great value. No difficulty is experienced generally in dilating the urethra up to 35

degrees or even 40 degrees. The object of this treatment is to open up the prostatic ducts and relieve a congestion of urethra and verumontanum. Instillation of two or three drops of a 5 per cent. solution of silver nitrate is indicated once every week or two, especially in cases associated with enlargement and congestion of the verumontanum.

In cases with marked sexual symptoms additional measures may be used, such as the topical application of 20 per cent. nitrate of silver to the verumontanum through an endoscope, the passage of a large metal sound, which is allowed to remain in the urethra for five minutes and thus make continued pressure against the verumontanum, and the use of the psychrophore, with either very cold or very warm fluid passing through it. General treatment for neurasthenia should also be carried out when indicated.

In cases with referred pains particular attention should be given during the prostatic massage to infiltrations around the prostate. I have seen numerous cases of long-standing lumbago and sciatica relieved by a few massages.

In cases with a chronic anterior and posterior urethritis the routine treatment above described is usually all that is necessary. In many cases anterior urethritis is perpetuated by frequent reinfections from the prostate, and with an improvement of the prostatitis anterior urethritis usually disappears. In some cases, however, it is advisable to examine the anterior urethra with the endoscope and perhaps make a few topical applications to diseased areas, and to dilate the anterior urethra after dilating the posterior urethra as above described. Massage of indurated areas upon a large sound is also of value in some cases, and special antiseptic irrigations and injections may occasionally be necessary.

Cases of obstructive prostatitis are sometimes markedly benefited by high dilatations of the prostatic urethra and vesical sphincter, which, with the improvement of the prostate produced by massage, may remove the difficulty in urination and even cause a disappearance of the residual urine. It is wise to try always the simpler methods for a protracted period and then to give the patient a rest to see what has been accomplished. In some cases, however, the obstruction and residual urine or contracture of the bladder persist, and more radical measures will have to be adopted to effect a cure. In such cases the median obstruction may be removed either by the Bottini operation or by prostatectomy, perineal or suprapubic, or by simple division of the bar through a perineal incision.

In forty-two cases of obstructive prostatitis in my series, local treatment was employed in twenty; the Bottini in five; perineal prostatectomy in thirteen, and four were not treated. The cases in which the Bottini operation was employed were less severe than those in which prostatectomy was done, and the results have been fairly satisfactory. The division of the inflammatory bar removed the difficulty in urination, allowed the bladder to empty, and gradually caused a disappearance of the vesical hypertrophy and contracture. The incisions were made with the small blade of my instrument and were generally not more than

2 cm. in length. One or two incisions were generally found sufficient. In cases where three incisions were used an incontinence persisted for several weeks.

The thirteen patients on whom conservative or partial perineal prostatectomy was performed were aged as follows: Two, thirty-two; two, thirty-seven; two, forty-four and forty-seven; and seven, over fifty years of age. The youngest patient, thirty-one years of age, had led a catheter life for two years, and one thirty-seven years of age, for twelve years; and in both of these cases the retention of urine was just as complete as in cases of great prostatic hypertrophy, although only a small inflammatory bar was present. In the other cases there was only a moderate amount of residual urine present, but the obstruction was marked and the irritability and contracture of the bladder considerable.

Five of these patients had suffered severely from pain for many years, and the prostate was markedly inflamed and numerous adhesions were present. All have been relieved by the operation, which has been very satisfactory, not only in completely removing the obstruction to urination, but also in causing a complete disappearance of the local and referred pains of severe character. The impairment of sexual power after the operation has been only transient, and two cases report that there has been a marked improvement as a result of the operation.

The cases of chronic prostatitis requiring operative relief on account of the obstruction present are generally those characterized by severe inflammation, induration, and periprostatic infiltration and adhesions, and for such cases the apparently simpler operations—the Bottini operation and perineal division of the bar—are generally not as satisfactory as prostatectomy, by which the enlarged indurated lobes can be partially removed, and the rest of the prostate drained through the perineum after the operation. In this way not only is the obstruction removed but the chronic prostatitis completely cured. Suprapubic prostatectomy is not to be advised because it is difficult to enucleate inflammatory enlargements, and it is possible to remove piecemeal through the suprapubic region only the median bar, so that very little more is accomplished than would be possible with simple perineal division.

The operation which I have employed in these cases is similar to that for cases of true prostatic hypertrophy—the ejaculatory ducts and urethra are preserved in a broad bridge of tissue between two longitudinal incisions about 1.5 cm. apart. If these incisions are made deep, no difficulty is experienced in removing the lateral lobes, each in one piece, as they shell out easily from the capsule. At their upper end a sharp periosteal elevator is usually of assistance in separating them from the bladder. The median portion of the prostate should then be inspected through one of the lateral cavities. It is always considerably above and well demarcated from the portion containing the ejaculatory ducts, and by piercing it with a sharp hook little difficulty is usually experienced in removing, partly by blunt dissection and partly by scissors, this hypertrophic inflammatory median mass without injury of the ejaculatory ducts and with only a slight tear in the urethra. The

sphincter is not disturbed, and as it is often of a cicatricial character it is well to insert the finger through it, and thoroughly dilate the prostatic orifice. In some cases it has been necessary to make a median incision or even excise a small portion, but care should be taken not to do too much, so as not to produce incontinence. If the vesical orifice is widely dilated after removal of the inflammatory median bar, it will usually suffice. If the examination before operation has shown considerable seminal vesiculitis, it may be well to expose, incise, and drain the seminal vesicles; I have done this in two cases. No difficulty is encountered in picking up the posterior surface of the vesicle and cutting a small window into it for packing and subsequent drainage, but numerous large veins surround the vesicles, and in one case considerable hemorrhage occurred. This, however, could have been controlled at operation had the necessity been realized.

The after-treatment in these cases is the same as for prostatic hypertrophy—continuous irrigation through two catheters which are removed at the end of twenty-four hours. The perineal fistula usually heals within a week or two, and some of these patients have left the hospital in twelve days. There have been no deaths and the results have been exceedingly satisfactory.

In four cases of severe chronic prostatitis, without obstructive symptoms, the operation of conservative perineal partial prostatectomy was performed. In these cases the median portion of the prostate was not disturbed. Three of these cases had been subjected to local treatment at my hands for a prolonged period without benefit, but the results obtained by operation were rapid and excellent; one of these patients has since married and become a father, and others report no sexual disturbance.

I feel justified, after a study of these seventeen cases of chronic prostatitis in which the operation of conservative perineal prostatectomy was performed, in saying that operative treatment is indicated in a certain small but very definite number of cases. Those cases with marked obstruction to urination cannot well be relieved by anything but operative intervention, and those with severe inflammatory changes which do not respond to local treatment, or may be associated with such painful symptoms as to prevent the administration of prostatic massage, can be safely and quickly cured by the partial excision and drainage afforded by the operation which I have proposed, and I believe that in the future we will come more and more to a conservative operative treatment for chronic prostatitis, many cases of which can otherwise be cured only after long months or even years of local treatment. The operation is naturally delicate and requires care and experience.

Tuberculosis of the Prostate.—The first definite description of tuberculosis of the prostate was apparently made by Boyle in 1808, but Dupuytren and Cruveilhier gave us in 1842 our first description of its pathology. Since then Vidal, Thompson, Simmonds, Orth, Marwedel, Saxtorph, and others have described cases of primary tuberculosis of the prostate.

As in other organs, the disease may be primary or secondary, the latter being much the more common form. In two hundred and five cases of chronic urogenital tuberculosis examined at autopsy, Saxtorph found nine cases in which the disease was present only in the prostate, no other foci being present in the body. In a series of twenty-six autopsies in cases of genital tuberculosis, Guyon found only one case in which the prostate alone was involved, two in which the seminal vesicles alone were involved, ten in which the prostate and seminal vesicles were both involved, and thirteen in which the prostate, seminal vesicles, and epididymis were involved. In one hundred and twenty-seven cases the prostate was involved in one hundred and seventeen, in fifty-six of which the infection was confined to the prostate. Burckhardt found the prostate diseased in 73 per cent. of the cases of urogenital tuberculosis, and Hallé and Motz in fifty-nine out of seventy-two cases. Albarran thinks that posterior urethritis is often a determining factor in primary tuberculosis of the prostate. Baumgarten holds that the spread of tuberculosis in the genito-urinary tracts was always with the secretion stream, and that the prostate thus became infected from tuberculosis of the kidney and also the epididymis, but never the epididymis from the prostate. Kantorowicz reported fifty-one cases of testicular tuberculosis in children, in only two of which the prostate was diseased. This infrequency may be explained by the lack of seminal secretion in children. In twenty-five cases of genito-urinary tuberculosis seen in private practice I found ten in which the disease was apparently primary in the prostate. When seen, however, the disease had spread either to the seminal vesicles or urethra in every case. In the other fifteen cases the prostate was secondarily infected from the epididymis or kidney.

Pathology.—All stages of tuberculosis are found in the prostate, viz., miliary tubercles, conglomerate tubercles, caseation, abscess formation, fibrous encapsulation, etc.

Miliary tuberculosis usually occurs along with a general infection and is seldom recognized except at autopsy. In primary cases the tubercles develop around the acini or their excretory ducts, but occasionally tubercles in the interglandular stroma have been encountered. According to Hallé and Motz, there is first an infiltration of embryonic cells beneath the basement membrane, which finally become confluent and lead to the destruction of the glandular epithelium, the acini thus becoming filled with proliferating and desquamated cells. A giant cell appears in the center of the periacinous infiltration, the cells break down, and caseation results. Simmonds says that the tubercle bacilli are most frequently seen between the basement layer of epithelial cells and the stroma immediately surrounding the acinus. By the fusion of small nodules larger ones are formed.

Two distinct types have been recognized, a central or periurethral form, and a peripheral form in which the disease is localized in the peripheral portions of the gland. The lesions are usually found in both lobes. Socin found both lobes involved thirty times in forty-four cases. In one case a caseous nodule was found in the middle lobe alone. The

nodules are usually multiple and small, but Albarran has described an abscess cavity which held 45 c.c. In rare cases the invasion is so intense that the entire prostate becomes caseated, forming a cystic caseous mass within its capsule. Marwedel has described such a case in which the entire gland formed a sequestrum and was undergoing calcification. The frequent finding of evidences of healing processes has been remarked upon by numerous observers, and several instances of apparent cure have been found at autopsy.

Beginning in the prostate the tuberculous processes may invade the ejaculatory ducts, the seminal vesicles, the vas, epididymis, and testicle, or the urethra and bladder. Invasion of the periprostatic tissues, the ischiorectal fossa, the rectum, and the peritoneum also occurs. In forty-four cases Socin found only one in which the rectum was invaded. Englisch has described a periprostatic tuberculosis without any invasion of the urogenital tract. The course of the disease in the genital tract is often quite interesting. Primary tuberculosis generally begins in the globus major of the epididymis. Later the body and globus minor become involved, and finally the prostate and seminal vesicle may become infected through the vas deferens. If now the opposite side of the scrotum becomes involved, I have almost always found the disease to locate primarily in the globus minor, as in gonorrheal epididymitis. In such cases it seems probable that the first infection is hematogenous in character and located in the globus major. When the opposite side is invaded, the disease travels down the vas deferens and thus infects first the globus minor. The lesions of the urethra are often extensive and involve sometimes Cowper's glands and other periurethral structures. The bladder often remains for a long time free from invasion, but ultimately infiltration of its walls, ulceration, contracture, etc., occur. An abscess may burrow toward the rectum, the perineum, or the peritoneum, and fistulas of various kinds may result—perineal, rectal, recto-urethral, rectovesical, etc.

Symptoms.—The symptoms may vary very much with the extent and position of the lesions. In many cases they resemble those of a simple prostatitis or urethritis in the earlier stages. When the urethra is invaded, distressing urinary symptoms usually come on, viz., frequent and painful urination, hematuria, strangury, etc., often simulating vesical calculus. At first the symptoms may be intermittent and periodic, with long intervals of no discomfort. More or less obstruction to urination with partial or even complete retention of urine occasionally occurs, generally due to the formation of an abscess and relieved by its rupture. Hematuria is often an early symptom, and in several of my cases was present before any irritability of the urethra or bladder developed. It is usually terminal and similar to that seen in posterior urethritis. Later the hemorrhage may become profuse. Hematospermia is occasionally seen. In cases in which the peripheral portions of the gland are considerably invaded pronounced rectal and perineal symptoms may be present. Defecation may be extremely difficult and painful and sometimes a tenesmus occurs at stool.

The various referred pains seen in chronic prostatitis may be present, viz., in the back, buttocks, hips and thighs (often following the sciatic nerve), and in the suprapubic, inguinal, and scrotal regions.

When the disease becomes extensive and accompanied by an invasion of the seminal vesicles, urethra, and bladder, the condition of the patient is often pitiable—micturition every few minutes, accompanied by great pain in the bladder, prostate, and penis, and various referred pains for which morphin often gives little relief. In many cases, however, with considerable involvement present, the patient is singularly free from severe symptoms. I have seen cases with very extensive invasion of prostate and seminal vesicles with very few urinary symptoms.

Diagnosis.—In the beginning of the disease diagnosis is extremely difficult owing to the frequent occurrence of chronic posterior urethritis and prostatitis. A small tuberculous lesion is rarely recognized. In the absence of chronic gonorrhea the finding of localized nodules in the prostate should be viewed with suspicion, especially if a slight hematuria and marked tenderness are present. A careful examination of the prostatic secretion obtained by massage should be made, and in order to avoid confusion with the smegma bacillus the penis should be thoroughly cleaned up and the anterior urethra irrigated with a slender glass tube or catheter previous to massage of the prostate and to urination. Studies made by Churchman and myself showed conclusively that if this is carefully done the smegma bacillus will never be found in the voided urine. The tuberculin test or animal inoculations may be necessary in some cases.

In the later stages of the disease diagnosis is usually easy, from the severity of the symptoms, the marked frequency and painfulness of urination, and the discovery of an enlarged, irregular, nodular, tender prostate, often associated with a similar condition of the seminal vesicles and membranous urethra. Some cases of severe chronic prostatitis closely simulate tuberculosis, but the prostate is rarely so irregular or so tender, though the induration may be greater. Efforts should be made to discover whether the disease is secondary to lesions in other portions of the urinary or seminal tracts by careful examination of the scrotal contents and of the kidneys, but cystoscopy and ureteral catheterization are usually not indicated unless there is distinct suspicion that one of the kidneys is involved. Ureter catheterization should then be done if possible, as it has been distinctly shown that nephrectomy is strongly indicated in all such cases. The urethroscope may occasionally demonstrate ulcerations and aid in the diagnosis, but it is usually too painful and too productive of trauma to be advised.

In carcinoma of the prostate the induration is usually more uniform and more stony in character, and the age of the patient is generally greater than that in which tuberculosis usually occurs. In some cases, however, the diagnosis may be difficult. Prostatic lithiasis, hypertrophy, or cysts, and vesical calculus, tumor, or ulcer, have also to be considered occasionally, but the diagnosis is usually simple.

Treatment.—*Hygienic.*—The now well-established methods of treat-

ing tuberculosis of the lungs and other regions of the body by hygienic measures are very valuable also in the treatment of tuberculosis of the prostate. An outdoor life, rest, proper attention to food and the general regulation of one's daily life are often of wonderful value in the treatment of prostatic tuberculosis. I have been unable to find any statistics to determine whether special climates or altitudes have any distinct advantage. They are apparently not so important as in cases of pulmonary tuberculosis. I have seen several cases with very extenisve tuberculosis of prostate, seminal vesicles, urethra, and bladder, with foci in the lungs, who are now remarkably improved after several years of outdoor life. In some of these cases the prostate now feels almost normal.

Local.—Guyon has advised the use of instillations of 1 to 5000 bichlorid of mercury when the urethra has become involved. Ichthyol, iodoform, and other medicaments have also been recommended, but their use is generally condemned; and the less urethral instrumentation and irrigation is done, the better it is as a rule. Opiates may be necessary to relieve the pain, and are usually best given in the form of suppositories in conjunction with hyoscyamus or belladonna.

Surgical.—In case of abscess formation, an incision through the perineum may be necessary, but unless the process is fairly extensive the operation should usually not be done. A study of the literature shows distinctly that attempts to remove the tuberculous foci in the prostate are usually more harmful than helpful. The fact that the ejaculatory ducts, portions of the seminal vesicles, and the urethra are usually involved shows the futility of attempting a radical excision. A chronic tuberculous sinus usually results, and most often urine escapes through it and the condition is worse than before. The results of vesiculectomy for tuberculosis have also been very unsuccessful, and the surgical world is pretty well agreed that operative procedures upon the prostate are not indicated. As remarked above, when the disease is secondary to tuberculosis of the kidney nephrectomy should be performed if possible. After removal of the primary focus the prostatic lesion often gets well. When the epididymis or testicle is involved, it should be removed. This is true when extensive tuberculosis of other organs coexists, as it has been distinctly shown that the removal of the external focus which pours a steady stream of pus into the prostate, by epididymectomy or castration, is often very beneficial. For several years it has been my plan to make the incision high up in the groin and to bring the vas deferens out of the upper angle of the wound, where it can be injected with iodoformized oil at the operation and at intervals of a few days afterward. In some cases the drainage of purulent material through the stump of the vas has persisted for several weeks, and this treatment as a whole has been very beneficial.

In some cases with severe urinary symptoms suprapubic cystostomy for temporary or even permanent suprapubic drainage may be advisable.

Hypertrophy of the Prostate.—History.—Although the prostate was first described by Massa in the sixteenth century, it was not until

the seventeenth century that Riolan discovered that obstruction to urination could be produced by its enlargement. His observation, however, was very little noticed. A little later, however, Morgagni gave an excellent description of the pathology and complications of certain cases of prostatic enlargement. Since then Hunter, Home, Brodie, and Thompson in England, and Civiale and Mercier in France, have been the pioneers in this field of pathology and surgery.

In recent years there have been many workers on the surgery of the prostate, among whom may be mentioned Mercier, who advocated snaring or destroying the median lobe through the perineum in 1856; Bottini, who introduced the galvanocautery treatment through the urethra in 1874; Küchler, who described a radical operation for prostatectomy which he carried out on the cadaver in 1866; Billroth, who practised this operation on the living subject in 1867; Gouley, who laid down the principles for enucleation of the prostate through the perineum in 1874; Leisrink, who in 1882 did the first total extirpation of the prostate and sutured the divided ends of the urethra; Belfield and McGill, who independently in 1887 enucleated the whole gland more or less completely through a suprapubic incision; Watson, who in 1888 published a handsome monograph demonstrating the possibilities of perineal prostatectomy; Goodfellow, who in 1890 began the first systematic enucleation of the gland through the perineum; Fuller, who in 1895 carried out systematic suprapubic enucleation of all the prostatic lobes; White, who in 1893 suggested castration, and Harrison, who introduced vasectomy in 1893.

In the past ten years there have been a vast number of articles upon the surgery of the prostate and numerous operative procedures have been advocated. Many of these have been attempted in only a few cases. Those which have won distinct recognition and are used to-day are as follows:

Methods of perineal prostatectomy as practised by Goodfellow, Alexander, Syms, Murphy, Ferguson, Bryson and Young. Methods of suprapubic prostatectomy as practised by Fuller and Freyer. The Bottini operation as carried out with the instruments of Freudenberg, Young, and Chetwood.

Pathology.—A review of the literature shows that numerous opinions have been expressed regarding the nature of prostatic hypertrophy and that many theories have been proposed to explain the pathologic processes present. The lobulated nature of the growth was recognized early and Virchow described them as hyperplastic myomata. Rindfleisch recognized two forms, one glandular and one fibromuscular. Velpeau was one of the first to call attention to the spheroidal nature of the tumors which one sees in hypertrophied prostates. Thompson recognized the existence of four varieties: (1) one showing simultaneous development of all the elements of the prostate; (2) the predominance of the stroma; (3) predominance of the glandular elements; (4) the formation of spheroidal bodies, which he compared to uterine fibromata.

In a study of one hundred prostates when the clinical diagnosis of

hypertrophy of the prostate had been made, Albarran and Hallé found four varieties of lesions, which they grouped as follows:

Glandular hypertrophies	32
Fibrous hypertrophies	3
Mixed hypertrophies	51
Prostatic epithelioma	14

Greene and Brooks disagreed with the findings of Albarran and Hallé and held that the epithelial changes upon which the diagnosis of epithelomata had been made had been found by them in many of their own cases which were undoubtedly not cancerous. Ciechanowski came to the conclusion that prostatic hypertrophy was almost always the result of chronic inflammatory changes, with which conclusion Greene and Brooks agreed.

In a recent contribution Motz has called attention to the fact that prostatic hypertrophy nearly always began in the glands close to the urethra on each side, and that the glands beneath the urethra and below the ejaculatory ducts are rarely enlarged.

The following notes are largely extracted from a study by Geraghty and myself of 120 specimens removed by perineal prostatectomy. Taking as a basis of classification the composition of the hypertrophy, we have been able to distinguish three types of cases: (1) Glandular, one hundred cases; (2) fibromuscular, fourteen cases; and (3) inflammatory, six cases.

The first two forms alone represent true hypertrophies. The inflammatory form is not a true hypertrophy, but we include it because it represents an important variety of obstructing prostate. Although here and there one encounters a picture typical of the glandular and the fibromuscular varieties, various transitions exist, and a clear-cut boundary-line cannot always be easily drawn between them. This classification which we have employed is not to be understood as representing distinct anatomic varieties, but rather types of cases which are but different phases of the same pathologic process.

Gross Appearance of Glandular Form.—When enucleated, the surface is usually lobulated and the consistence is generally soft and elastic. On cutting into such a prostate the tissue may be more or less sponge-like, owing to dilated glandular acini, while here and there are seen the gaping orifices of small retention cysts which have been cut across. An abundance of secretion oozes forth. Usually the cut surface presents the picture of numerous spheroidal tumors, differing in size, separated from each other by encircling and interlacing bands of tissue of a denser character and of varying thickness. These spheroidal lobules project beyond the surface and are sometimes distinctly encapsulated and can be quite readily enucleated. At times the tendency to spheroid-formation is indistinct and the picture presented resembles that of a diffuse glandular hypertrophy.

On microscopic examination the gland tissue for the most part occurs in lobules, and when these are not present the acini seem to be segregated in well-defined areas. The acini are usually dilated, often elongated or ovoid, and with rather complex lumina due to infolding and often papillo-

matous-like proliferation of the lining wall (Fig. 212). The epithelium lining the acini presents a variety of pictures. One acinus may be lined by a double layer of cells, the internal being a high cylindrical type with the nucleus near the basal end and an internal layer of rather cuboidal shaped cells. Again, there may be but a single layer of high cylindrical cells. In the culs-de-sac where proliferation is active there may be beneath the layer of cylindrical cells numerous layers of polygonal shaped cells. Very often in the same acinus at one point a single layer of cylindric cells may be seen and at other points accumulated heaps of small epithelial cells. The interacinous stroma is composed of fibrous and muscular tissue in varying amount. Acini which have undergone cystic degeneration are frequently encountered. These acini are usually lined by a single layer of flattened epithelium, and rarely give evidence of a prolifera-

FIG. 212.—THIS REPRESENTS A PICTURE COMMONLY SEEN IN THE GLANDULAR FORM OF HYPERTROPHY.
The acini are for the most part dilated and several have undergone cystic dilatation. Epithelial proliferation is active.

tive activity. About the periphery of the spheroidal lobules the tissue is, as a rule, condensed, fibrous in character, and contains acini, most of which are compressed and elongated.

Fibromuscular.—The fibromuscular forms seldom reach the large size attained by the glandular. The largest in our series weighs 25 gm. The consistence is much firmer than the glandular, but it never has the induration which one encounters in the carcinomatous prostate. On section it is less succulent and distinctly more homogeneous in appearance, although isolated spheroids are noted, which may be mostly, if not entirely, composed of a fibrous or fibromuscular tissue. The dilated orifices of the acini are sometimes seen and occasionally small retention cysts are noted.

On microscopic examination the acini are regular in outline, separated

by broad bands of stroma, and seldom show many signs of active gland proliferation (Fig. 213). They are sometimes dilated, but seldom display the degree of cystic degeneration seen in adenomatous hypertrophies. The stroma varies, connective tissue predominating in one and muscle in others.

Under the *fibrous* or *inflammatory form* of hypertrophy we have included a very interesting group of cases with marked prostatic symptoms and partial or complete retention of urine, but with very little enlargement of the prostate. On gross examination they contain no spheroids;

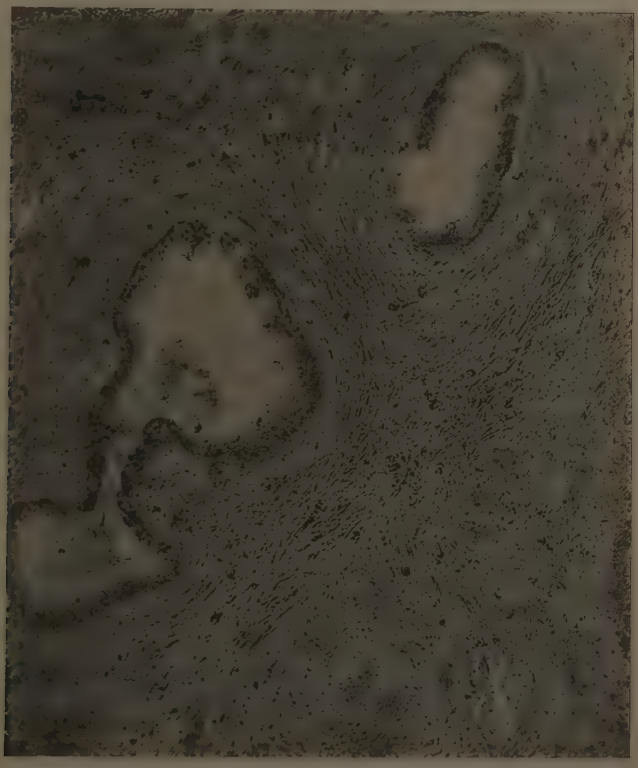

FIG. 213.—REPRESENTS A FIBROMUSCULAR FORM OF HYPERTROPHY.

the cut surface is more homogeneous and fibrous. The prostatic obstruction is a result of inflammatory processes which produce a fibrous hyperplasia about the vesical orifice or result in the formation of an inflammatory median bar. The microscopic examination of the median bar in these cases has always demonstrated its inflammatory nature, while the lateral lobes present no changes other than those noted in chronic prostatitis. Chronic inflammatory processes have been found very frequently in our cases, but as a large percentage of the patients were suffering from chronic cystitis one would expect prostatitis to be a frequent complication. A well-marked prostatitis was present in 58 per cent.; a slight prostatitis

with a few limited areas of inflammation in 31 per cent.; no prostatitis at all in 11 per cent.

We have already referred to the views of Ciechanowski regarding the rôle which prostatitis plays in the production of prostatic hypertrophy. A review of Ciechanowski's cases shows that he was dealing almost entirely with small prostates found at autopsy, while ours were cases of obstruction requiring operation. If Ciechanowski's views as to the etiology (obstruction of the excretory ducts) were correct, one would expect to find the acini generally dilated and lined by flattened epithelium, but such is not the case.

Chronic prostatitis with the production of a large amount of fibrous tissue is generally accompanied by atrophy of the gland elements. In our examinations the areas in which the chronic inflammatory processes were most marked had only a small number of acini, and these were often compressed and atrophic. At times nothing but vestiges of former acini remained. Furthermore in 11 per cent. of our specimens no evidence of any inflammatory processes were found, and in the vast majority of cases where prostatitis was present the inflammation was confined to limited areas, most of the hypertrophied tissues being free from it. The arteriosclerotic theory of Guyon is also untenable.

Development of Prostatic Hypertrophy.—The different steps in the formation of the new gland acini can often be followed in one section. The initial activity is in the epithelium, resulting in a protrusion or folding of the epithelial lining toward the lumen of the acinus, the knuckles of epithelium projecting into the lumen without a supporting pedicle of stroma. At other points one sees delicate fibrils of connective tissue accompanying the epithelial proliferation, and at a later stage fibers of smooth muscle entering into the composition of the pedicle of the new-formed villus. By the continued growth of these protrusions the acinus becomes subdivided and new acini are formed. If the glandular activity is very pronounced, the interacinous stroma may consist entirely of delicate fibrils of connective tissue, but where the proliferation is slower the stroma is more abundant. It is probably the primary activity of the epithelium which stimulates the connective tissue and muscular elements of the stroma to activity. Prostatic hypertrophy is not a diffuse hyperplasia of all portions of the prostate, but one which begins in separate foci and results in the formation of numerous spheroidal tumors. As the hypertrophy in the central portion increases, the peripheral tissue is condensed, thus forming a pseudo-capsule (Fig. 216). It is inside this pseudo-capsule that the usual enucleation is performed. In the compression of the peripheral portion of the prostate the ejaculatory ducts are pressed toward the posterior surface, so it is easy to understand why in some cases of suprapubic prostatectomy the ejaculatory ducts are not destroyed. The subcervical and prespermatic portions can be removed without disturbing them.

Malignant Degeneration.—Albarran and Hallé found what they considered malignant changes fourteen times among a hundred prostates obtained from autopsies at Hôpital Necker in which the diagnosis of

benign hypertrophy had been made. It was only on microscopic examination that these supposed evidences of malignancy, to which they have applied the term "epithelioma adenoid," were found.

In our one hundred and twenty enucleated specimens of prostates which were thought to be benign, and in which on gross examination no suspicion of malignancy was entertained, in only one was distinct carcinoma found on microscopic examination. In this prostate a small carcinomatous nodule about 2 mm. in diameter was noted in an otherwise benign prostate. We have not infrequently found areas of active gland proliferation in which the epithelium lining the acini and the intra-acinous papillary projections presented a rather wild profusion and showed some slight involution changes, but we do not consider these sufficiently marked to warrant a diagnosis of carcinoma. It seems probable that all of the changes described by Albarran and Hallé should not be considered malignant, since benign adenomata display many epithelial variations, some of which may closely simulate malignancy.

FIG. 214.—A CROSS-SECTION OF A PROSTATE WHICH REPRESENTS AN EARLY STAGE OF HYPERTROPHY.

The small spheroidal tumors have formed in the central portion and are compressing the tissue immediately surrounding them.

The following conclusions seem warranted: Prostatic hypertrophy is of neoplastic nature, and in most cases is of an adenomatous or fibromyoadenomatous form. Pure myomata and fibromata are occasionally seen. The characteristic lesion of hypertrophy is the formation of spheroidal tumors which arise in the central group of glands. The primary activity is in the epithelium of the acini. Chronic prostatitis may produce obstruction similar to true prostatic hypertrophy, but does not lead to a true hypertrophy of the gland. Cancer rarely begins in a benign hypertrophy.

Mechanical Changes.—These may perhaps be best understood by a progressive description of the lesions which are encountered. In the great majority of cases the enlargement is produced by the growth of one or more spheroids in the prostate, as shown in Fig. 214. These spheroids are round or oval masses surrounded by a somewhat indefinite fibrous capsule and composed largely of glandular elements which have undergone active proliferation. The most common location for the beginning spheroid formation is along either side of the urethra in the substance of one of the lateral lobes, as shown in Fig. 214, in which two small spheroids are shown on opposite sides of the urethra. It will be noted here that the urethra is flattened from side to side by the pressure of these growths, but that the prostate is not definitely enlarged. In Fig. 215 a later stage is shown, in which large spheroids are present along with smaller ones which are developing elsewhere. The prostate is enlarged, the urethra flattened from side to side and considerably increased

antero-posteriorly, so that it presents the shape of a long, inverted Y. Fig. 216 shows a still later example of spheroid formation. Here numerous spheroids are seen closely crowded together with little intervening tissue and completely occupying the substance of the two lateral lobes. Surrounding them externally a definite thick capsule is seen. This capsule, which is much thicker than in the normal prostate, is composed not only of fibrous and muscular elements, but also remnants of gland tissue which have been packed together by the outward pressure of the growing spheroids. Briefly, then, the formation of prostatic enlargement, as usually seen, consists in the growth of an increasing number of spheroids surrounded by an artificially produced thick capsule and leading to distortion of the urethra in various ways from the pressure of the growing masses.

FIG. 215.—A CROSS-SECTION OF A HYPERTROPHY SOMEWHAT MORE ADVANCED THAN THAT SEEN IN FIG. 214.

In the lower portion are visible the ejaculatory ducts and the dilated orifices of some gland acini.

In the simplest form there may be only an enlargement in one of the lateral lobes, which may flatten the urethra and cause it to deviate toward the opposite side; this form, however, is very rare. More commonly we find an enlargement on both sides of the urethra, which is flattened between them and lengthened antero-posteriorly, as seen in Fig. 216. In such cases the prostate is usually increased in all of its diameters, but at operation only two globular masses, which are composed of numerous spheroids, are found; one on each side of the urethra. In such cases that portion of the prostate beneath the urethra and the ejaculatory ducts is rarely enlarged. In the earlier stages the enlarged lateral lobes do not project into the bladder, but in rare instances they project anteriorly toward the symphysis pubis, greatly increasing the antero-posterior diameter of the prostate, but forming a prostate the size of which is not indicated either on rectal examination or with the cystoscope (I have seen two such cases). As a rule, however, enlarged lateral lobes soon begin to project into the bladder, where they appear as globular outgrowths covered with smooth mucous

FIG. 216.—THE HYPERTROPHY HERE IS ADVANCED STILL FURTHER THAN THAT SEEN IN FIGS. 214 AND 215.

The central portion is entirely replaced by the hypertrophied tissue, while the peripheral portion assumes the rôle of a thickened capsule in the periphery. The ejaculatory ducts are seen toward the posterior surface.

membrane, but with no intervening layer of muscle. Dissection in such cases shows that the vesical sphincter lies external to these outgrowths, which have evidently grown into the bladder from the urethra, thus dilating and pushing the vesical sphincter outward. This is an important point, because it allows the enucleation of these lateral enlargements without the destruction of the vesical sphincter. The size reached by such lateral enlargements is often very considerable and occasionally huge. I have seen cases in which the lateral lobes projected far into the bladder, so that they presented the appearance of two hemispheres with their flat surfaces compressing the greatly widened and flattened urethra between them, and with no enlargements of other portions of the prostate present.

The most common variety consists of the enlargement of the median and lateral lobes. The lateral portions of such an enlargement are similar to that which has been previously described. The median enlargement occurs in that portion of the prostate in front of the ejaculatory ducts and beneath the urethra adjoining the vesical orifice. In its earliest form this usually appears as a slight thickening of this portion of the prostate. In such a case, if the vesical orifice be viewed from within the bladder, it will be found to be elevated a little more than usual above the trigone and less dilatable than usual, exhibiting a definite constriction when an attempt is made to insert the finger into the urethra. In such cases the vesical orifice has the appearance of a transverse slit or inverted crescent, the latter being the later stage. As the disease progresses there may form either a more prominent transverse bar with a deep pouch in the trigone behind it, or a more rounded median lobe, which at first projects only slightly into the bladder, but may finally assume very great size, sometimes as large as an orange. Such an enlargement of the median portion of the prostate is due to hyperplasia of the glandular elements in front of the ejaculatory ducts, and in its growth it pushes the urethra upward, forming a valve-like (ball valve) obstruction, and finally enters the bladder cavity. The mucous membrane of the urethra lies in front of it and the vesical sphincter behind it. This point can frequently be demonstrated during perineal prostatectomy, in which the removal of the median lobe can nearly always be accomplished without injury to the vesical sphincter, which can be easily palpated posterior to the cavity left by the removal of the median lobe. The fact that the sphincter is posterior to these globular median enlargements confirms me in the belief that enlargements of this character arise from hyperplasia of the prespermatic suburethral group of glands and not the subcervical group of glands (as held by Albarran), which are immediately beneath the mucous membrane of the trigone adjacent to the vesical orifice and above the vesical sphincter. I feel certain that if these median lobe enlargements arose from the subcervical group the vesical sphincter would be found in front of them, and it would not be possible to remove them through the perineum without destroying the sphincter.

Observation of autopsy specimens has seemed to me to show that these enlargements come first from the intraurethral part of this portion of the prostate and below and anterior to the vesical

sphincter. In the earlier forms of such triple enlargement (of lateral and median portions) the median lobe alone is seen at the vesical orifice, and, as remarked above, the urethra is in the shape of a transverse slit with a bar beneath it, or an inverted crescent with a rounded lobe in the median portion. Later on, when the lateral enlargements project into the bladder, the three lobes are squeezed together by the vesical sphincter which surrounds them, so that sulci of varying depths are produced where these separate lobes come in contact with each other. Thus three sulci are usually produced, one anteriorly between the two lateral lobes and one on each side, where lateral and median lobes meet. In some instances the intravesically enlarged lateral lobes form a continuous mass with the median lobe on one or both sides, and in such cases there will be little or no sulcus between one or both of the lateral lobes and the median bar. The presence or absence of sulci in these diagnostic positions is of great importance, as will be shown when the cystoscopic study of the intravesical portion of the prostate is taken up.

Enlargements of the median portion of the prostate alone occur, but much more rarely than the form of enlargement above described. In such cases the changes are similar to those described above for the median portion of the prostate, and consist in the formation of either a bar or a lobe. In the case of a bar it may occasionally assume the shape of a thin septum rising well above the level of the trigone and also of the prostatic urethra, which generally presents a sharp bend in front of the bar. Such cases are usually associated with a sclerotic or strictured condition of the vesical sphincter, sometimes requiring great force before the index-finger can be introduced. The globular forms may be sessile, attached to the prostate by a broad base, or they may be more or less pedunculated, the pedicle in some cases being long and narrow and allowing the lobe to drop backward upon the vesical trigone. In rare instances the median lobe may be of such huge size as to more or less completely fill the vesical cavity.

Enlargements of the anterior commissure of the prostate are rare, but do occur. They are usually present in the shape of small globular outgrowths which project into the bladder in front of the urethral orifice. Most often they are continuous with one of the lateral lobes of the prostate, and in such cases it seems probable that they are in reality lateral enlargements which have assumed an irregular outgrowth in the bladder. I have seen a specimen in the Museum of the Royal College of Surgeons, in which there is an enormous enlargement of the prostate, consisting entirely of a hypertrophy of the tissue of the anterior commissure of the prostate. In this case the urethra formed a flattened canal on the inferior surface of a large oval, anterior, intravesically projecting mass, but there was no enlargement of the lateral and median portions of the prostate present. In the three hundred and fifty cases of hypertrophy of the prostate in which I have operated I have never seen a similar condition.

Symptoms.—During its long evolution prostatic hypertrophy follows a fairly definite cycle, and it is usually possible to discern very distinct

periods: (1) The period of urinary troubles, increased frequency and difficulty of urination. (2) A period of chronic incomplete retention of urine without distention of the bladder and generally with some contracture of that organ. (3) A period of incomplete retention with vesical distention and often intermittent complete retention of urine, requiring the use of a catheter. (4) A period of continuous complete retention of urine and catheter life.

According to Albarran, during the first period the troubles are of a dynamic and congestive order, but in the other periods the phenomena are mechanical. Additional phenomena may appear in all of the periods, —such as vesical infection, calculi, tumor, diverticula,—and add additional symptoms to those which are present in the regular evolution of the disease, but there is also a wide variation of the symptoms presented and in their order of appearance.

In an analytic study of one hundred and forty-five cases which I published in the "Johns Hopkins Hospital Reports," vol xiv, frequency and difficulty of urination were shown to be the most frequent initial symptoms, occurring in about 60 per cent. of the cases. At the beginning both of these symptoms are, as a rule, very slight in character, and the onset is so gradual that it is difficult for the patient to say when urination began to be abnormal. The increase in frequency is generally recognized first at night. In many cases the frequency and difficulty of urination are intermittent in character.

Pain was noticed as an onset symptom in twenty-five cases. In twelve there was only a slight burning in the urethra during urination and in three pain was merely the discomfort produced by severe straining to void urine. Eight of the twenty-four cases complaining of pain had calculus of the bladder, and in two of these cases a history of previous renal colic was obtained. In one peculiar case the only symptom for nineteen years had been painful erections at night, and although the prostate was quite large there was no urinary disturbance. In seven cases the first symptom was a sudden hemorrhage; only one of these cases suffered with calculus, and in several instances the hemorrhage occurred at repeated intervals. Complete retention of urine was the first symptom in eight cases, most of them requiring catheterization for a protracted period, but it is interesting to note that in four of these cases the complete retention came on ten years or more before admission to the hospital, but none of these cases became dependent upon the catheter.

Incontinence of urine was the first symptom in eight cases. In three cases this condition persisted up to the time of operation, but was present only at night, and during the day the patient had no difficulty or even frequency of urination, although the catheter showed a greatly overdistended bladder.

The course of the disease is, however, as a rule fairly regular, beginning with frequency of urination at night, slowness in starting the flow of urine, and a smallness in the stream. This condition generally persists for some time with very little change, but ultimately the calls to arise at

night and the difficulty of urination by day become gradually more and more marked, and finally the patient finds himself some day unable to respond to the call of urination. The use of morphin or hot sitz-baths often causes sufficient relaxation to allow natural urination, and the patient may have no further attack of complete retention for quite a period. Generally, however, catheterization is required, and when once done usually has to be repeated for several days, and not infrequently ever afterward the patient has to lead a catheter life. The first use of the catheter generally marks a change in the symptomatology, owing to the fact that it is usually not done with proper aseptic precautions, and infection of the bladder results, and is followed by cystitis and the painful symptoms which generally accompany it. Vesical calculus is also much more apt to occur when the bladder has become infected than when it is sterile, and this also leads to painful symptoms which greatly aggravate the disease. In rare instances, although the amount of residual urine is large, the patient suffers very little change in the act of micturition, and I have seen cases in which more than 1000 c.c. residual urine was present in which the patient's only complaint was abdominal distention, and the discovery of a greatly dilated bladder first called attention to the possibility of there being any urinary trouble. As a rule, the progress of the case is associated with intermittent attacks of complete retention of urine, requiring the catheter, the use of which often becomes permanently fixed upon the patient and he leads a "catheter life."

In these one hundred and forty-five cases, twenty had never been catheterized and in forty-five the retention of urine had never been complete. Complete retention of urine occurred at some time in sixty-four cases, and in seventy cases the catheter was more or less regularly employed at the time of admission, on account of incomplete retention of urine. In thirty-five cases the retention of urine was complete and the patients led catheter lives. In a few of these cases (nine) the catheter was required only two or three times daily, but in the others it was required more frequently, and in several it had to be used so often, both night and day, that it became a frightful burden. Catheter life, in fact, was shown to be, in most instances, a horrible affair, and associated with numerous and frequent complications. Strange to say, the ability to follow a comfortable catheter life did not come as a result of the use of aseptic precautions; frequently under the best technic severe cystitis was present, while occasionally with the most dirty methods of catheterization the patient suffered very little inconvenience.

Digestive disturbances are not rare, especially in cases of enlarged prostate associated with considerable residual urine, and are probably due to the back pressure upon the ureters and renal pelves leading to inefficient action of the renal cortex. In some cases it amounts to only a lack of appetite, slight indigestion, and constipation. In other cases there may be a feeling of slight nausea, occasionally associated with vomiting. Such cases are very apt to have a "urinary cachexia," which is due not only to the digestive disturbances, but also to the systemic poisoning and to the inefficient elimination by the kidneys. When there

is a definite infection of the kidneys present, this condition of uremia is apt to be most marked, the complexion is bad, the urinous odor of the breath is marked, the nausea often considerable, and the presence of the slight febrile attacks, sometimes preceded by chills, is not uncommon, so that they present a definite septic cachexia. In some cases other systemic symptoms are present, such as headaches, impairment of vision, and marked nervous depression.

Not infrequently the patient has considerable pain and discomfort in the rectum, owing to the presence of the enlarged gland, which may thus partly obliterate its cavity and make the act of defecation distinctly difficult, but occasionally there is severe pain in the rectum and perineum. When prostatitis and inflammatory infiltration around the prostate and seminal vesicles are present, we often see painful symptoms referred to other regions, particularly the back, hips, thighs, and legs. In such cases the symptom-complex is not unlike that seen in carcinoma of the prostate, and in rare instances these referred pains far outweigh the urinary symptoms. Hemorrhoids and inguinal hernias are very frequent results of the straining to void urine.

Disturbances of the sexual apparatus are not uncommon. Occasionally the power of erection is impaired or completely lost. Coitus may be unsatisfactory owing to precocious or painful ejaculation. This is particularly true in cases associated with calculus. It is a remarkable fact, however, that there is much less sexual disturbance than occurs in chronic prostatitis, and a surprisingly large number of cases report that their sexual powers are apparently normal.

In my series of one hundred and forty-five cases the sexual powers in patients under fifty years of age were normal in all cases. Between fifty and sixty years of age erections were normal in 78 per cent. and coitus normal in 74 per cent. Between the age of sixty and seventy erections were normal in 55 per cent. and coitus normal in 38 per cent. Between seventy and eighty years of age erections were present in 32 per cent. and coitus normal in 21 per cent. of the cases. In not a few cases the principal fear of operation was that it would destroy the sexual power.

In the early stages of development there are no symptoms of obstruction and often only slight irritation to suggest that there is any lesion present. Later there is definite obstruction, showing itself as a slight hesitation at the beginning of urination and a diminution in the size and force of the stream. This is generally accompanied by a hypertrophy of the vesical muscle, which thus compensates for the obstruction, and enables the patient to empty his bladder; but this muscular hypertrophy, as a rule, leads to contracture of the size of the vesical cavity, and as a result urine is voided more frequently than normal. The vesical capacity in many cases becomes reduced one-half or even three-fourths. After a while complete evacuation of the bladder becomes impossible; residual urine is constantly present, generally in gradually increasing amount. In some cases the bladder still remains contracted and the working space—that is, the difference between residual and vesical capacity—becomes very small and urination is therefore very frequent.

In other cases the bladder gradually dilates as the amount of residual urine increases, and in some instances reaches huge size. In one of my cases the bladder contained 4500 c.c. of urine. I have seen a number of cases where patients voided urine without marked difficulty when a residual urine of from 1000 c.c. to 2000 c.c. was present. Complete retention is often due to an acute congestion, after the disappearance of which there may be no further complete retention for a very long period. It is generally, however, intermittent in character, but, as remarked before, in some cases the retention remains complete.

Incontinence of urine, which is occasionally present, is generally associated with a large residual urine. It is in reality an overflow, and apparently due to incomplete closure of the lumen between the enlarged lobes. In some instances there will be a large chink left between two irregular outgrowths, and through this the urine escapes. It is very rare indeed to find incontinence of urine with an empty bladder, and in most cases it is present only at night, probably owing to a dropping back of a pedunculated median lobe.

Formation of pouches, cellules, and diverticula begins early in the disease; they are the result of the intravesical tension. Efforts of the bladder to force urine through the obstructed urethra produce hernias of the mucous membrane between the hypertrophied muscle bundles of the vesical wall. The pouches appear most commonly behind and on each side of the trigone. Cellules are found scattered all over the posterior and lateral walls of the bladder, and in some cases are very numerous. Diverticula occur most commonly in three locations—just external to the ureteral orifices and at the vertex of the bladder, in the region of the urachus. While the cellules are usually small and lie entirely within the muscular wall of the bladder, diverticula project beyond the external surface and frequently reach great size. The explanation for their presence near the urachus and the ureters is that the bladder is weakest at these points, owing to the separation of the muscle bundles to allow the passage of the ureters and urachus into the bladder cavity. I have elsewhere reported a series of cases of vesical diverticula which proved a very remarkable complication to prostatic enlargement, and in some instances required operative treatment.

It is probable that quite soon after the development of marked obstruction to urination the intravesical pressure makes itself felt upon the ureters and renal pelves. A very marked dilatation of these structures is often seen when the prostatic enlargement is not very great. The advent of bacterial infection of the bladder is of serious moment on account of the frequency with which an ascending infection results. The presence of diverticula is also important, owing to the fact that they often press upon the lower portions of the ureter and produce flexures which lead to marked obstruction and ureteral dilatation.

Physical Examination.—The usual examination of the patient should, of course, be made, and the condition of the arteries, heart, lungs, and abdomen described. Particular attention should be paid to the kidneys to determine whether any enlargement or tenderness of these organs

is present. The hypogastric region should also be carefully examined for a distended bladder and the groins and genitalia carefully noted.

Rectal Examination.—After the patient has voided as much urine as possible the index-finger of the right hand, covered with a thin rubber cot, should be lubricated and inserted into the rectum and a careful study of the size, shape, consistence, and sensitiveness of the prostate, the seminal vesicles, the intervesicular space, the membranous urethra, the tissues around the prostate and vesicles, the rectum, and the pelvic lymph-glands made.

The rectal findings are so variable that it is difficult to describe the various conditions which may be found present. In the ordinary adenomatous hypertrophy the prostate is more or less considerably enlarged, bulges toward the rectum, sometimes considerably diminishing its cavity. The surface is generally smooth, the lateral lobes often equally enlarged, the consistence elastic and often soft. There is very little tenderness and no evidence of periprostatic infiltration nor induration of the seminal vesicles nor the intervesicular space, and no enlargement of the pelvic lymph-glands. As a rule, the median furrow and notch can still be recognized, but in some instances both are obliterated. The finger can generally reach the upper end of the prostate except in very great hypertrophies, and in most cases the posterior surface of the bladder and the seminal vesicles can be satisfactorily palpated. In cases where there is a very large amount of residual urine present the bladder is often considerably depressed, so that it is much closer to the anus, presses much farther toward the rectal cavity, and gives one the impression of a much larger prostate than is really present. In a few instances the surface is irregular, presenting a lobule which projects either from the posterior surface or upward from the base of the prostate. In such cases subsequent examination has shown that a spheroidal growth has broken through the capsule and penetrated the periprostatic tissues. In only about 10 per cent. of the cases have I found the posterior surface irregular and never in very marked degree. It has usually been impossible to determine by rectal examination the size or character of the median lobe, the cystoscope being necessary in order to determine how much this portion of the prostate is enlarged.

In my series of one hundred and forty-five cases the prostate was described as distinctly soft in fifty-six; elastic in twenty-six; firm in forty-five; moderately hard in fourteen; very hard in no cases. The seminal vesicles were slightly indurated in nineteen cases; moderately indurated in five cases. The intervesicular space was slightly indurated in two cases; moderately indurated in two and the whole base of the bladder was hard in one case. Glands were palpable in the pelvis in five cases. The size of the prostate in those cases in which it was soft was generally considerable. In the forty-five cases in which the prostate was described as firm there were no areas of marked induration present, but the prostate was elastic and uniform in consistence. In the fourteen cases classed as moderately hard the consistence was quite firm, but not of stony hardness. In these cases the consistence was not uniform, there

being places of greater induration than others. The induration was generally most marked at the upper end, along the region of the ejaculatory ducts and adjacent to the bases of the seminal vesicles. The complete absence of cases of stony hardness is interesting as showing an important differentiation between carcinomatous and benign enlargements. Subsequent examination has shown that in those cases in which the prostate is very little enlarged, distinctly indurated, and a little irregular, inflammatory changes are generally present, and in some cases the lesion is obstructive hypertrophic prostatitis and not a definite hypertrophy. The symptoms, however, are often as severe or even worse than those accompanying adenomatous hypertrophy of the prostate, and in many instances much more painful. In such cases the rectal examination will often show very little evidence of enlargement, and without cystoscopic examination a positive diagnosis cannot be made.

Instrumental Examination.—Catheter.—After the patient has voided his urine as completely as possible a catheter should be passed under proper precautions. As a rule, it is well to be ready to carry out a cystoscopic examination immediately afterward, and the patient should be placed on a table suitable for this work. The genitalia should be thoroughly cleaned with soap, water, bichlorid of mercury 1 to 1000 solution, and everything but the glans penis covered with an antiseptic towel. After the urethra has been irrigated with sterile water it is well to inject about 15 c.c. of a 4 per cent. solution of cocain in order to deaden the sensibility of the urethra. After this has been injected and the meatus compressed, pressure upon the urethra will generally force the fluid back into the prostatic urethra and bladder, thus cocainizing the entire tract. After two or three minutes a coudé gum catheter, about No. 16 F. in size, should be introduced. The sharp bend of these prostatic catheters generally makes it easy to pass them over an enlarged median lobe. In cases where false passages have been produced or marked irregularities are present, it may be necessary to try other catheters; first, gum catheters of other sizes; then Nélaton rubber catheters, or finally a silver catheter with or without the prostatic curve. Great care should be taken to use as little force as possible, in order to prevent hemorrhage.

When the catheter enters the bladder the amount of residual urine present should be carefully noted, and then the bladder capacity determined by filling the bladder as full as possible with sterile water. Repeated washings may now be necessary in order to cleanse the bladder, but as soon as the fluid comes away clear the cystoscope, which has been sterilized in pure carbolic acid, sterile water, and 1 to 20 carbolic acid solution, is then introduced. In many instances the Nitze cystoscope has proved to be the instrument most easily introduced, and only on rare occasions has it been impossible to pass it. After its introduction into the bladder attention should first be directed to finding the ureters. By watching the outflow of the urine from their orifices a very good idea can generally be obtained as to the comparative amount, value, and character of the urine ejected from them. In cases of unilateral pyonephrosis the purulent urine from the infected side can easily be

detected. In some instances it is impossible to find the ureters, owing to the fact that they lie concealed behind a large median lobe. The study of the bladder should comprise the condition of the mucosa, amount of trabeculation present, pouch formation, intramuscular cellules, and perivesical diverticula. A careful search for vesical calculi should be made and neoplasms should be excluded. After the condition of the ureters, kidneys, and bladder has been determined, attention should be directed to the prostate. The cystoscopy of the prostate is recognized to be very difficult. This is due to the fact that in the ordinary Nitze cystoscope the direction of the view is at right angles to the shaft of the instrument, and in order to study the prostatic orifice it is necessary to withdraw the instrument until the prism is partly within the prostatic urethra, as shown in Fig. 217. In this position it is possible to view only about one-sixth of the prostate margin at one time, and therefore in order to see the condition on all sides it is necessary to take at least six consecutive views. The study is further complicated by the fact that owing to the close proximity of the prostatic margin to the cystoscopic prism the structures are greatly magnified, are turned upside down, and somewhat distorted by the spherical aberration present.

Fig. 217.—Position of Cystoscope when Viewing Margin of Prostatic Orifice.

In a study of many cases I have found it advisable to make use of a special chart in which eight circles are provided for the views obtained around the prostatic orifice. The views obtained in a normal prostatic orifice are shown in Fig. 218. As remarked above, these are considerably magnified, and inverted, so that in order to get a correct idea of the orifice each figure will have to be inverted.

The shape of the prostatic orifice depends upon the pressure which is brought to bear upon it by single or multiple enlargements of the various portions of the prostate. These are generally outgrowths of one or both of the lateral lobes or of the median lobe. Only rarely does one find enlargement of the anterior commissure of the prostate. The changes which occur may be shown diagrammatically, as in Fig. 219: *a* represents the normal prostatic orifice; *b*, the orifice compressed between two enlarged lateral lobes; *c*, a median lobe pushing the urethra upward; *d*, a single anterior lobe (rare); *e*, hypertrophy of the median and both lateral lobes; *f*, hypertrophy of an anterior and both lateral lobes; *g*, enlargement of four portions of the prostate, anterior lobe, two lateral lobes,

and a median lobe; *h*, the median and right lateral lobes confluent, that is, forming a single large mass (two sulci being present, one between the two lateral lobes and one between the left lateral and median lobe);

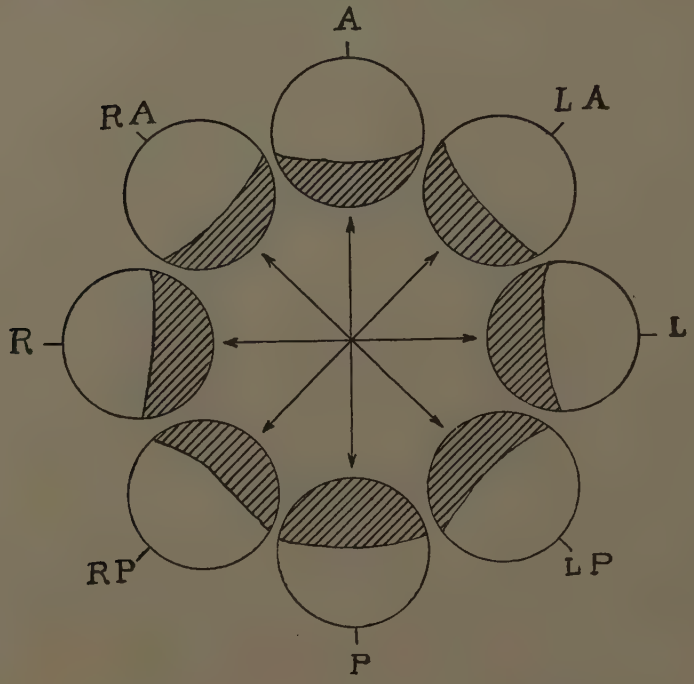

Fig. 218.—Views of the Normal Prostatic Orifice.

i, the opposite, the median lobe being confluent with the left lateral; *j*, the median enlargement in the shape of a bar which is confluent without intervening sulci with an enlarged lateral lobe on each side; *k*, an enlarge-

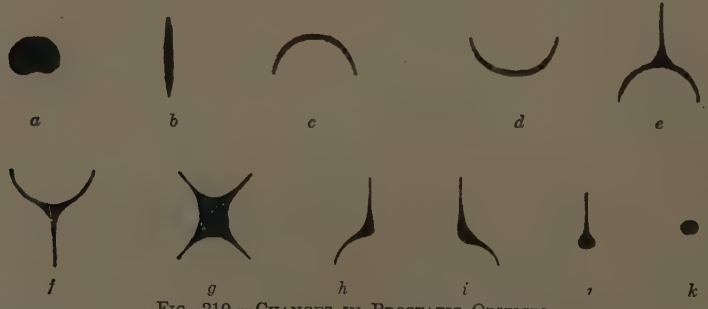

Fig. 219.—Changes in Prostatic Orifices.

ment all around the orifice leading to circular contraction without intervening sulci.

Our limited space prevents a full study of the multiple pictures presented in the cystoscopic study of cases of prostatic hypertrophy. By

use of the cystoscopic chart, above described, and bearing in mind the changes in the orifice shown in Fig. 219 it is possible to form an accurate idea of the character and disposition of the intravesical enlargements present. A few examples may suffice to show some of the pictures presented. Fig. 220 shows enlargement of both lobes. Fig. 221 shows a small median lobe. Fig. 222 shows median and lateral enlargements. Fig. 223 shows a median bar confluent with both lateral lobes. In cases of median lobe enlargement of small degree the cystoscope will usually remain on the summit of the median lobe and the sulci on each side are distinctly shown. If the median lobe is moderately large, and with a deep sulcus on each side, the cystoscope will usually slip to one side or

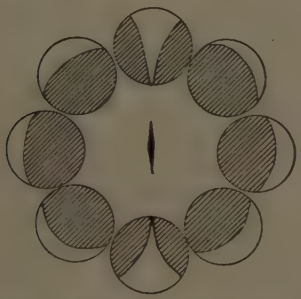

FIG. 220.—HYPERTROPHY OF THE TWO LATERAL LOBES.

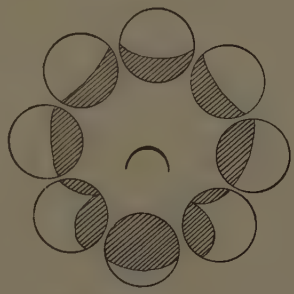

FIG. 221.—SMALL MEDIAN LOBE.

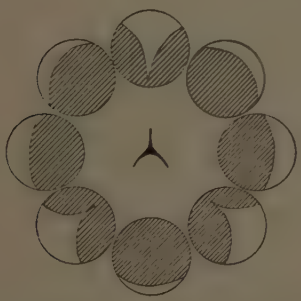

FIG. 222.—MEDIAN AND BILATERAL LOBES.

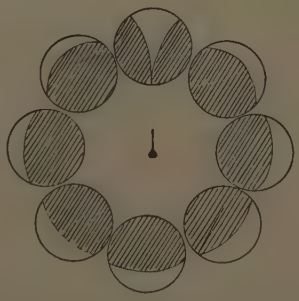

FIG. 223.—MEDIAN CONFLUENT WITH BOTH LATERAL LOBES.

the other of the median lobe into one of these sulci, and very puzzling pictures will be obtained unless care be taken.

By the use of this cystoscopic chart, however, one is able to get a very accurate idea of the size and configuration of the intravesical prostatic enlargements, and information of very great value, especially when operation is to be performed, is obtained. The cystoscope is also of great value in determining the presence or absence of calculi, diverticula, or tumors, and the condition of the kidneys, and should always be made use of, for without it the operator is working in the dark. Before removing the cystoscope from the bladder it is advisable to insert a gloved finger into the rectum and carefully examine the tissues between it and

the cystoscope. It is usually very easy to palpate the beak turned backward, and thus make out the condition of the trigone and the tissues beneath it. Passing the finger downward, the thickness of the suburethral tissues can be determined. A large median bar is usually very evident, but in case of a pedunculated median lobe the cystoscope usually slips into the sulcus to one side of the lobe, and the true size of the median hypertrophy is therefore not to be made out with the finger in the rectum. By turning the beak toward the position of the ureteral orifice it is usually possible to determine whether there is any induration present in this region, and sometimes intramural calculi can be felt.

The cystoscopic study of one hundred and twenty-five cases showed as follows: *Median lobe:* Slight bar, thirty-nine; slight round lobe, thirty-seven; moderately enlarged, twenty-seven; considerably enlarged, fourteen; greatly enlarged, two; hugely enlarged, one. *Right lateral lobe:* Not intravesically enlarged, eleven; slightly enlarged, fifty-five; moderately enlarged, twenty-eight; considerably enlarged, seventeen; greatly enlarged, two; huge, one. *Left lateral lobe:* No enlargement, thirteen; slight, fifty-two; moderate, twenty-five; considerable, nineteen; great, two; huge, one. *Anterior lobe:* Present in five cases, always of slight degree. Contracture all around the orifice, one case. Intraurethrally projecting lobes, four cases. Vesical calculi present, twenty-five cases. Vesical diverticula present in seventeen cases. Pouches and cellules, numerous cases.

Urinalysis.—In the earlier cases no abnormality of the urine will usually be detected, but later on it is often of low specific gravity, low urea content, and a definite polyuria is present, generally most marked at night. The urine is usually cloudy with pus and bacteria, only eighteen of my one hundred and forty-five cases showing clear urine. The reaction was acid in one hundred and eleven of these cases; alkaline in fourteen, and neutral in five. Albumin is usually present, but generally due to pus or blood, though sometimes it is of such extent after filtering to indicate the presence of nephritis. In ten of my cases granular casts were present, but, as a rule, it is almost impossible to detect the presence of nephritis owing to the pus or blood.

The general condition of the patient is usually far from good. This is due to the fact that the patient is an old man. In my series of one hundred and forty-five cases, 31 per cent. were over seventy years of age; sixteen cases were between seventy-five and seventy-nine years of age; four between eighty and eighty-four years of age, and one eighty-seven years of age. Eighteen cases were in a very weak condition and one had developed the morphin habit. In seven cases there was a marked emphysema of the lungs; arteriosclerosis was very common, in six cases marked, in one case associated with angina pectoris, and in another hemiplegia. In twenty-two cases heart murmurs and other evidences of endocarditis were present, and in eight cases the heart was enlarged. Pyelitis was present in six cases and nephrolithiasis in two. Five patients were suffering from uremia, in two cases of very severe type.

Diagnosis.—The diagnosis of prostatic hypertrophy is generally so

simple that it seems almost superfluous to say anything in regard to it. The presence of frequency and difficulty of urination coming on after fifty years of age, and getting progressively worse, often leading to the use of a catheter, the discovery of a much enlarged gland on rectal examination, residual urine with the catheter, and intravesically hypertrophied lobes with the cystoscope, makes the diagnosis at once evident. Many cases, however, are not typical, and in some the diagnosis is very difficult. In cases where although the symptoms are typical rectal and cystoscopic examinations fail to show any enlargement the diagnosis generally lies between chronic prostatitis, spinal cord disease, and prostatic hypertrophy of the periurethral type. In prostatitis there is usually little or no residual urine, and the frequency of urination is generally due to irritability rather than obstruction. The urinary symptoms are usually intermittent in character, there being fairly long periods of comfort between occasional severe attacks of irritation, frequency of urination and pain. In some cases, however, chronic inflammation leads to the production of a definite bar in the median portion of the prostate, and the obstruction may assume such marked degree that not only large residual urine, but even complete retention requiring a catheter life may ensue. I have seen this in five cases, all the patients being fairly young men. Not infrequently the two diseases occur together; this is especially true in cases where the prostate has become infected by the use of a catheter and chronic inflammatory changes are engrafted upon a previously hypertrophied prostate. In such cases the symptomatology may be that of the two diseases. The use of the cystoscope is of particular value in cases in which the rectal examination shows very little enlargement, for in many such cases, in which it would be impossible to make a diagnosis of prostatic hypertrophy, the cystoscope shows a definite median lobe at the vesical orifice.

Spinal Disease.—Various lesions of the spinal cord may produce symptoms closely simulating those of prostatic obstruction, and recently I have had several patients sent to me for operation in whom the spinal cord was responsible for the condition present. In certain cases of locomotor ataxia there is a gradually increasing residual urine associated with difficulty and frequency of micturition, and finally complete retention, requiring the use of a catheter. As a rule, however, incontinence is one of the early symptoms and generally associated with more or less incomplete evacuation of the bladder. Other symptoms, such as an ataxic gait, shooting pains, loss of sexual power, and the other characteristic symptoms of tabes, are usually present, but in some cases the urinary symptoms are the first to appear, and in such cases diagnosis may be extremely difficult. This is especially true when the prostate is definitely hypertrophied. As a rule, however, the rectal examination will show a very flabby condition of the muscles of the perineum, a weak anal sphincter, a redundant rectum, a soft unenlarged, movable prostate. Residual urine is generally present, sometimes in large amount, and the cystoscope shows generally more or less marked trabeculation of the vesical muscle, with intervening depressions, cellules, and occasion-

ally diverticula. Study of the prostatic orifice, however, generally reveals in cases of tabes no enlargement of either the median or lateral portions of the prostate, and in some cases a dilated internal sphincter, so that it is possible to examine with the cystoscope the prostatic urethra. The presence of extensive vesical trabeculation and pouch formation, which are certainly signs of obstruction to urination, is probably due to a spastic condition of the external sphincter, which fails to respond to the calls to urinate and remains closed while the vesical muscle attempts to evacuate the bladder. In cases of lateral sclerosis of the cord diagnosis is often still more difficult, and we have not the space to discuss the urinary symptoms produced by the various spinal cord lesions. Suffice it to say that early loss of sexual powers and incontinence of urine should make one strongly suspect spinal disease, and the presence of patellar reflexes is not sufficient to exclude it. It is very important that a very careful neurologic examination be carried out in most cases. The only two cases in which incontinence persists among my cases of perineal prostatectomy are two which now show definite evidence of spinal sclerosis. In some cases the nervous symptoms far outweigh the urinary, and symptoms of urethral, perineal, and rectal irritation cause much more discomfort than the obstruction to urination. Such cases are nearly always associated with chronic prostatitis, and not infrequently the more remote reflex pains which are so common in that disease are present, viz., lumbago, sciatica, vague pains in the hips, groins, scrotum, and even more remote regions of the body.

Cancer of the Prostate.—The differential diagnosis between benign and malignant prostatic disease is usually very easy in later cases in which the seminal vesicles, glands, perirectal and other pelvic structures are extensively involved. In the early cases, however, diagnosis is often extremely difficult, and as the possibility of a radical cure in cases of carcinoma can only be undertaken when the disease is recognized early, the extreme importance of a correct diagnosis is evident. Marked induration should always make one think of the possibility of cancer, and if this is of stony hardness, a positive diagnosis can gradually be made. A careful study of eighty-seven cases of carcinoma of the prostate showed that the disease remained, as a rule, for a long time within the confines of the lobes; the urethra, the bladder, and especially the posterior capsule of the prostate resting inviolate for a considerable period. Extra-prostatic invasion nearly always occurs first along the ejaculatory ducts, in the space immediately above the prostate between the seminal vesicles and the bladder and beneath the fascia of Denonvilliers. Thence it may invade the trigone, through which it sometimes appears as an intravesical tumor. In most cases the induration is uniform, involving both lobes of the prostate and the intervening posterior commissure. The posterior surface of the prostate is usually smooth, but later may become irregular and nodular. In rare instances a portion of the prostate is soft, but here again the very marked induration present in the affected portion should at once suggest malignancy. On attempting to pass a catheter, obstruction is generally encountered near

the apex of the prostate. This is due to a circular constriction of the entire prostatic urethra, the lumen of which is thus considerably narrowed. This is in marked contradistinction to the condition present in benign hypertrophy, in which the circumference of the urethra is generally increased, although it may be distorted and flattened by the pressure of hypertrophied lobes. A coudé gum catheter is generally the best instrument to use in cases of prostatic hypertrophy, but in cancer it is often impossible to pass such a catheter, and a small Nélaton rubber catheter is much the better instrument. In doubtful cases the cystoscope is of very great help because it usually shows no intravesical enlargement of the prostate in cancer, or at most only a slight elevation of the median portion of the prostate. As stated above, the bladder is usually found free from the disease until late, and then invasion is generally evident as an elevation of the trigone or an intravesical tumor, most often in the region of one or both ureteral orifices. In a small proportion of cases intravesically enlarged lateral lobes are present. Of considerable diagnostic value also is the examination of the tissues between the cystoscope and a finger in the rectum. In carcinoma the entire length of the posterior commissure is usually markedly thickened and indurated, while in hypertrophy the thickening is generally only in the region of the middle lobe. When the carcinoma has invaded the tissues immediately beneath the trigone, it is impossible to feel the beak of the instrument in the bladder, while in hypertrophy the subtrigonal tissues are usually soft and the beak easily felt.

In cases where a positive diagnosis cannot be made operation should be advised, with the idea of early diagnosis and proper treatment. After exposing the posterior surface of the prostate, palpation will generally show whether the condition is malignant or not, but sometimes it is advisable to incise the lobes and examine a section of tissue either by naked eye or by stained frozen sections. If the disease is shown to be malignant and it has not progressed far above the prostate, the radical operation described elsewhere may be undertaken; if benign, a conservative perineal enucleation can be carried out.

Cases of benign hypertrophy associated with marked chronic prostatitis, and especially with concretions and small calculi, are sometimes difficult to differentiate from cancer, and in such cases the methods described above should be undertaken. The fact that about 20 per cent. of the cases of prostatic obstruction in elderly men are due to malignant disease shows the great importance of early diagnosis, which is now seldom made. The presence of vague pains in the pelvis or lower extremities should always lead to an examination of the prostate, and if this were always done, many early cases of carcinoma would be recognized. Sarcoma of the prostate is an extremely rare disease, and in the three cases which I have seen has been characterized by a very large, soft, smooth tumor, which occupied a large part of the pelvis.

Treatment.—The treatment may be divided into hygienic, palliative, and radical. Under hygienic treatment may be placed all those things which we ought not to do if we want to preserve our good health. Sexual

excesses should be avoided, as statistics seem to show that undue indulgence in coitus is a definite etiologic factor. When the enlargement already exists, the patient should lead a very careful life, should not drink much alcohol, should be careful not to allow the bladder to become overdistended or chronic constipation to exist. When symptoms of marked irritability are present the use of appropriate mineral waters or diuretic remedies, and sometimes the occasional residence at some spa, are of distinct value.

Palliative.—Under this head may be mentioned prostatic massage and catheterism. In early cases, and especially those associated with chronic prostatitis, the use of vigorous prostatic massage once or twice a week for a protracted period may be of distinct service. Under such treatment much of the irritation and reflex painful symptoms often disappear, and I have seen a few cases in which a distinctly hypertrophied gland became small and the obstruction to urination less. As a rule, however, it is necessary to continue this treatment indefinitely, and in most cases other measures ultimately have to be adopted.

Catheterism.—The use of large dilating instruments has proved so unsatisfactory that they are now seldom employed. The traumatism produced at the vesical neck often aggravates the condition, and such treatment is not to be recommended. When the retention of urine is complete, catheterization is imperative, and often when once begun has to be continued. When the amount of residual urine is large, it is a distinct menace to health, and many authors recommend systematic catheterization when over four ounces of residual urine is found; the larger the residue, the more frequent the catheterization. When the patient is so situated that catheterization can be done well, its use is often accompanied by marked benefit and only a moderate amount of discomfort. The patient may find it necessary to withdraw the urine only two or three times a day, the cystitis which is invariably produced may be of only moderate degree and show no painful symptoms, and the general condition of the patient may remain good; but even under such favorable circumstances the patient's life revolves around the catheter, and this often proves an intolerable nuisance. In most cases, however, catheter life is far from pleasant; a severe cystitis generally ensues, with its train of disagreeable symptoms; vesical calculi not infrequently develop, accompanied by pain and hemorrhage. Occasionally it is very difficult or impossible to pass a catheter, traumatism of the urethra results, and sometimes great vesical distention is present before the patient is finally relieved by catheter or by suprapubic puncture. Casper has shown, after a careful study of catheter life, that it is far from satisfactory, and has an attendant mortality which is very considerable, and Rovsing reports ten deaths in one hundred and twenty-six cases so treated. In my series of one hundred and forty-five cases the catheter was used in seventy-six cases. Catheterization was often very difficult and painful and the patient usually found it an intolerable nuisance. The best catheter for cases of prostatic hypertrophy is a coudé gum catheter of French make, which can be boiled ("Porgés"), as shown in Fig. 224.

The "elbowed" curve which this instrument carries at its vesical end is best calculated to ride over the enlargements of the median portion of the prostate, which are usually present. If care is taken, little difficulty is found in passing a catheter between the lateral lobes of the prostate, which are easily pushed apart by the end of the catheter; but when the median portion of the prostate is reached, a straight instrument will, as a rule, come up abruptly against the anterior surface of the median bar or lobe, and further passage is often impossible. On this account the soft-rubber Nélaton catheter is often very difficult to introduce.

Fig. 224.—Gum Prostatic or Coudé Catheter which can be Boiled.

In certain cases the ordinary coudé catheter will not pass, and we then have the excellent instrument of Guyon, the mandarin coudé, shown in Fig. 225, which gives extra curve to the gum catheter and facilitates its passage. Such an instrument, however, is not to be given to a patient, nor is a silver catheter, but both may be necessary to the physician who is attempting catheterization. When the use of a catheter is thought advisable, it should be done under proper aseptic and antiseptic precautions, and the patient should take 10 to 20 grains of hexamethylamin

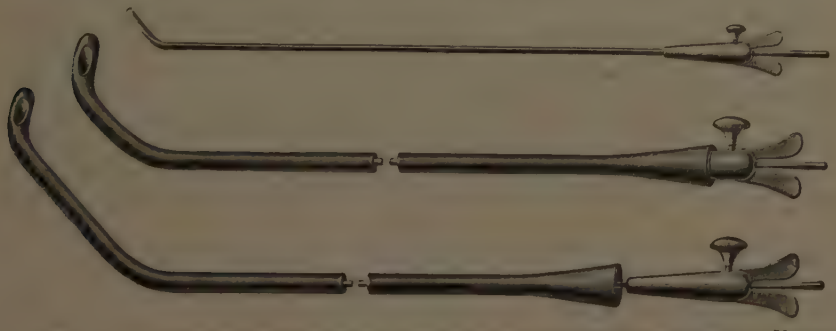

Fig. 225.—Guyon's Stilet to Facilitate Introduction of Catheter in Prostatic Hypertrophy.

and an intravesical irrigation of boric acid daily in order to keep down vesical infection and inflammation.

Statistics show, however, that aside from its discomfort the catheter life is far more dangerous than an early operation, and whenever it becomes evident that one is dealing with a definite hypertrophy of the prostate with considerable residual urine and obstruction, it is certainly advisable to carry out a curative operation. The fact that it is possible to have one hundred and twenty-eight consecutive cases without a death, many of the patients being infirm old men, and with many complications as a result of long-continued catheter life, shows that with an early operation the mortality should be *nil*, and the chances of restoring the

patient to a practically normal condition, without the complications produced by vesical infection, excellent.

In Emergencies.—Under emergencies may be included attacks of sudden complete retention of urine; the inability to pass the catheter as usual by patients leading a catheter life; traumatism due to catheterization, false passages, hemorrhage, periurethral and prostatic infections; extravasation of urine; perineal and rectal fistulas; severe inflammations of the bladder or diverticula from the bladder; ascending infections of the ureters and kidneys with the attending uremic complications. Space forbids any extended discussion of this subject, and the particular form of emergencies met with will have to be handled according to the dicta of modern surgery. In the case of the first complete retention, if the

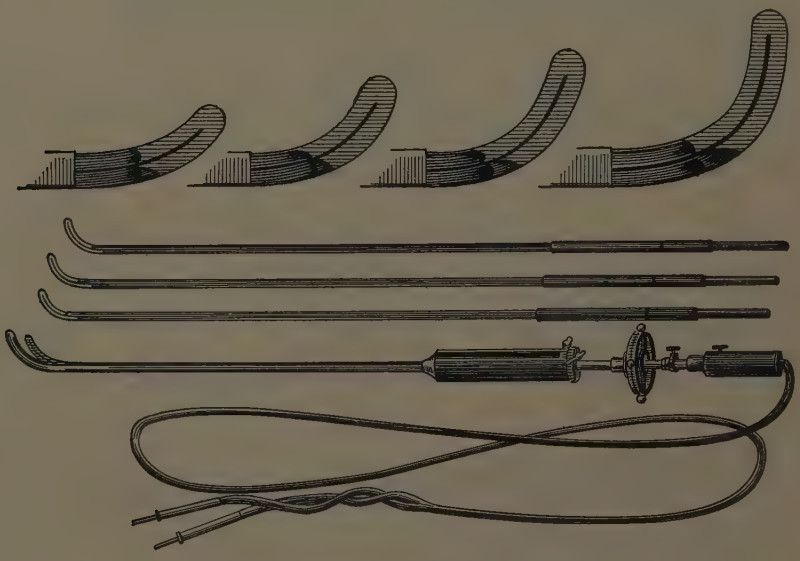

FIG. 226.—YOUNG'S MODIFICATION OF FREUDENBERG'S INSTRUMENT FOR PROSTATOTOMY BY GALVANOCAUTERY.

bladder is greatly distended, most authors think that it is dangerous to completely evacuate the bladder.

Radical Operations.—The galvanocaustic operation, which was introduced by Bottini in 1876, can hardly be considered a radical operation, in that the enlarged prostatic lobes are not removed, but the results obtained are generally so permanent that it deserves a place among the radical procedures. This operation is performed with an instrument provided with a platinum blade which can be heated by an electric current and then drawn through the prostate by turning an external screw in the handle of the instrument which lies in the urethra. Several days after the operation a slough is passed, and this usually provides sufficient opening for the free evacuation of urine. The early instruments of Bottini were very crude, but they were subsequently improved by himself, by Freudenberg, Young, Chetwood and others. They consist

essentially of a male blade carrying a platinum knife which can be heated to a white heat by electricity, and a female blade through which a current of water can be passed to prevent heating of this part of the instrument and consequent burning of other portions of the urethra. Freudenberg's instrument is the one most widely used, and has been modified by Young so that blades of different height can be used, the size to be selected according to the size of the prostate (Fig. 226). Chetwood's instrument (Fig. 227) is much shorter and is intended only for an operation done through a perineal section. Whether employed through the entire urethra or through the perineum, the operation consists in slowly drawing the platinum blade, heated to a white heat, through the prostatic tissue. As a rule, three cuts are made—one posteriorly through the median lobe, and one laterally on each side through the lateral lobes. The length of the incisions should be in accordance with the size of the prostate, which should be most carefully determined before operation by

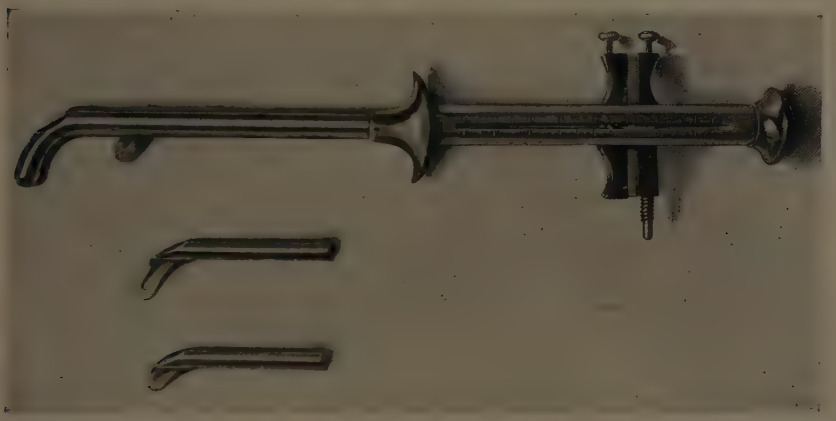

FIG. 227.—CHETWOOD'S GALVANOCAUTERY PROSTATIC INCISOR FOR USE THROUGH A PERINEAL OPENING.

cystoscopic examination, and particularly by palpation of the prostate with the cystoscope in the urethra. The size of blade employed should also depend upon the previous estimation of the size of the prostate. In prostates of slight enlargement the smallest blade, about 1 cm. high, should be used, and the length of the incisions should usually not be over 2 cm. While making these incisions the index-finger of the right hand of the operator should be in the rectum so as to be sure that the beak of the instrument does not slip into the urethra. About two minutes should be occupied in making each cut with the blade at white heat. In cases of moderate hypertrophy a blade about 1.3 cm. high should be used and longer incisions may be employed (varying from 2.5 to 3 cm.). In the very large prostates the largest blade, about 1.6 cm. high, may be employed with incisions 3 to 4 cm. long. Before using the largest blade the operator must be certain that the median portion of the prostate is greatly increased in thickness and that the enlargement is not merely

of the lateral lobes. In cases with a transverse median bar or a slightly rounded median lobe the posterior incision is usually entirely successful in removing the obstruction, but when the median lobe is pedunculated in character the beak of the instrument is likely to slip to one side of it, and when the posterior incision is made the median lobe usually escapes unhurt, and numerous operators have reported failures in such cases. In order to obviate this the writer has in several cases made use of two posterior incisions, each of which was placed obliquely across the base of the median lobe, thus partly cutting off its blood-supply and dropping it back against the trigone, where it can produce no obstruction. The results obtained in these cases have been entirely satisfactory. The operation can usually be done under cocain (4 per cent. solution in bladder and urethra, washed out before the operation). After the instrument is removed the patient is directed to void urine, which he can often do without difficulty. In such cases it is not necessary to insert catheters to be retained; in others it is wise to use a *catheter à démeure* for several days.

The subsequent treatment of the case consists in quiet, an abundance of water, some urinary antiseptic, and catheterization if necessary. As a rule, urine can be voided, but generally with some difficulty until the sloughs are passed. This occurs, as a rule, within a week after the operation. There is usually not much hemorrhage, the residual urine rapidly diminishes, and in most cases fairly normal micturition is established. Many brilliant results have been reported as a result of the Bottini operation, often in men of very advanced years and in desperate condition, and the cure has been maintained for many years. But while the Bottini operation is in most cases a simple affair followed by excellent results, the mortality is surprisingly large, and the number of failures is not small. Freudenberg's statistics, which are the most complete, show 85 per cent. good results, 55 per cent. cured, 30 per cent. improved, 8 per cent. bad results, and 7 per cent. fatalities.

I have personally had eighty-five cases in which I have performed the Bottini operation, and the results have been about the same as those obtained by Freudenberg. In many cases they were brilliant, but in others they were not, and the occurrence of several deaths in patients in excellent condition caused me to abandon the operation. That it has a place in surgery, however, cannot be denied. It is certainly very applicable to cases of median bar formation and so-called "small sclerotic prostates or contracture at the neck of the bladder," as has been most distinctly shown by Chetwood. The fact, however, that it is not always successful; that the prostate continues to grow in size, not infrequently leading to subsequent obstruction, and the presence of a considerable mortality, taken in connection with the fact that it is an operation performed in the dark, have relegated the Bottini to a secondary place in the treatment of prostatic hypertrophy.

Suprapubic Prostatectomy.—The first operation of this character was performed by Amussat in 1827, in the course of an operation for stone, but it was not until 1880 that the removal of a portion of an obstructing prostate as a routine procedure was first advocated by Dittel,

and he did not carry out the idea until 1885. Belfield performed his first suprapubic prostatectomy in 1886, and published his description of the operation in 1887. A great impetus was given by McGill, who in 1888 warmly advocated suprapubic prostatectomy, and in 1889 reported twenty-four cases.

The operations performed by Belfield and McGill were partial prostatectomies—a removal by enucleation or instruments of the middle lobe, or at most that portion of the lateral lobes surrounding the prostatic orifice, and as the procedures were incomplete the results obtained were not always successful.

That the first complete suprapubic prostatectomy was done by Eugene Fuller, of New York, in 1894, is well established, and we cannot understand why some of his fellow-countrymen should have given the credit for this to Freyer, who made his "discoveries" five years later, and after he had attended a meeting of the International Medical Congress in Paris in which Guiteras described the details of the method which was employed by many of us in America. I was with Guiteras, and in fact participated in the writing of his paper, so that I can substantiate his assertions that if Freyer did not then learn the method from him, he failed to avail himself of his opportunities.

Fuller's operation was described as follows: The patient is placed flat on his back and the bladder is distended with from 8 to 12 ounces of fluid. The bladder is then opened suprapubically, the forefinger of the left hand introduced, and the vesical opening of the urethra located. Scissors are slipped along the left forefinger to the urethral opening, and are made to cut through the median bar or lobe. The cut extends from the lower margin of the internal vesical opening of the urethra backward for an inch to an inch and a half, and into this one of the forefingers, whichever the operator may find convenient, is slipped, while at the same time the fist of the other hand makes firm counter-pressure against the perineum. By means of this counter-pressure the prostatic growth is brought well into the reach of the forefinger of the other hand, which is employed all this time in enucleating the prostatic obstruction *en masse*, or lobe by lobe, as the case may be. Enucleation can be easily and speedily accomplished in this manner, and should not be desisted from until all the lateral and median hypertrophies, as well as all hypertrophies along the line of the prostatic urethra, have been removed. The vesical walls at the base, as elsewhere, are very elastic and dilatable, so that it will be found that the little cut made through the bottom of the bladder will be large enough to admit of the passage through it of the enucleated prostate. A perineal incision is then made and a large size (No. 26 American) soft-rubber tube is passed through it into the bladder. After this, hot-water irrigation is employed for some minutes to wash out blood-clots and to stop oozing. Then the suprapubic wound is closed by a deep layer of catgut which includes the bladder wall, and by a more superficial layer of silkworm-gut sutures.

"I can say of my method of enucleation that by it the prostatic hypertrophy can be easily and thoroughly removed without damage to the

structures composing the vesical neck, and that hemorrhage resulting from it has always been of little consequence. The after-treatment consists largely in careful and thorough vesical irrigation in conjunction with the internal administration of a large amount of diuretic water in order to keep the kidney secretion free and active."

In 1900 Fuller made the following statements: "As a result of much further experience with this method I still find it perfectly satisfactory. I have, however, encountered numerous instances in which the hypertrophy was so fibrous and adherent that I could not enucleate it in the manner described. In such cases I have made my incision with the serrated scissors through the vesical base as has been described, and have with the finger-tip dissected the bladder wall free from the hypertrophy, after which prostatectomy forceps have been introduced into the bladder, through the dependent vesical incision, and made to grasp the hypertrophy under the guidance of the finger-tip, especial care being taken that none of the vesical wall is included in the bite of the instrument. After a mass is once so seized it can be removed by the direct cutting action of the forceps, which should be repeated till all obstruction is removed."

An important modification of Fuller's operation was that described by Guiteras in his paper on the status of prostatectomy in the United States before the International Medical Congress, Paris, 1900: viz., the use of one or two fingers in the rectum (instead of the first against the perineum, as employed by Fuller) to push up and steady the prostate while the enucleation is performed from above. I can personally testify to the great assistance afforded by such intrarectal counter-pressure, as I had been using the method since 1898, and had spoken of it in papers before several societies. Fig. 228 shows the beginning of such an operation—the capsule being stripped from the median lobe. If care is taken to first separate the urethra from the median and lateral lobes, it is generally possible to remove none of the urethra. I have numerous specimens showing no attached urethral or vesical mucosa. In one specimen, however, the entire prostate with the urethra and anterior commissure came away in one piece. Watson reports a similar case and shows an excellent photograph of a specimen removed in 1897, three years before Freyer's "discovery."

The following description, taken from Freyer, gives the details of the operation and subsequent treatment so well that it is published at length:

"A stiff gum catheter is inserted into the bladder, which is then washed out and left distended with boracic solution; the nozzle of the syringe employed for this purpose, and which is filled with the solution, is inserted into the end of the catheter, thus acting as a plug to prevent leakage from the bladder, and the syringe being ready to further distend the bladder with fluid if necessary as the operation proceeds. An incision, varying in length from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches according to the stoutness of the patient and the size of the prostate, is made in the median line of the abdomen, and a vesical incision about an inch long made in the vertical direction toward the symphysis. On withdrawal of the scalpel the forefinger is introduced

into the bladder, and if any calculi are present they are at once removed by forceps or scoop. The forefinger of the other hand is then introduced into the rectum to render the prostate prominent in the bladder, and to to keep it steady during the manipulation by the first hand. The mucous membrane over the most prominent portion of one lateral lobe or over the so-called middle lobe is scored through by the sharpened finger-nail and gradually detached by it from the prominent portion of the prostate in the bladder. This portion of the enlarged prostate is covered merely by mucous membrane, so that when it is scraped through and detached the true capsule of the prostate is at once reached. Keeping the finger's point in close contact with the capsule, the enucleation of the prostate

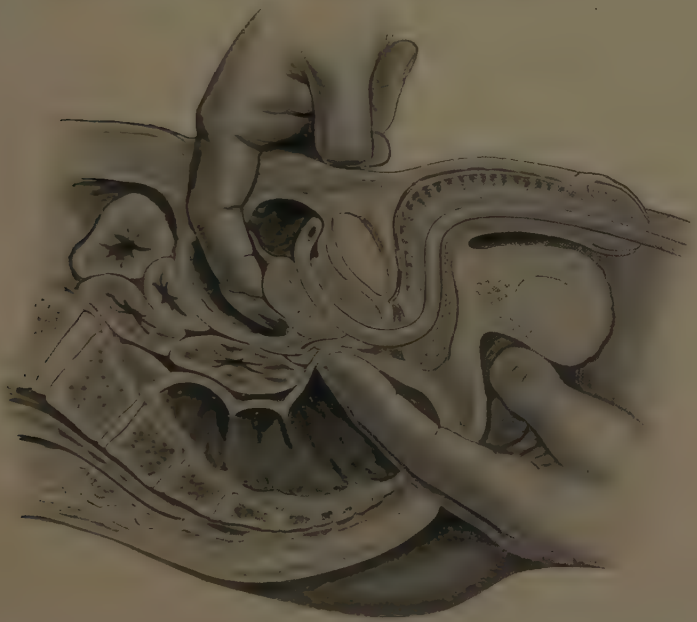

FIG. 228.—SUPRAPUBIC PROSTATECTOMY.
Sagittal section of pelvis, showing finger enucleating the prostate from its sheath, as counter-pressure is made by the other hand in the rectum (after Deaver, modified).

out of the enveloping sheath outside of the bladder is proceeded with by insinuating the finger-tip in succession behind, outside, in front of one lateral lobe, thus separating the capsule from the sheath. The finger is then swept in a circular fashion from without inward, in front of and to the inner side of the lobe, detaching this from the urethra, which is felt covering the catheter, and is pushed forward toward the symphysis between the lateral lobes, which will, as a rule, have separated along their anterior commissure in the course of the manipulation. The other lobe is attacked and treated in the same manner. The finger is next pushed well downward to the prostate and the inferior surface of the gland is peeled off free within its sheath and separated from the urethra. With the finger in the rectum, aided by that in the bladder, it is pushed into the bladder

through the opening in the mucous membrane, which, during the manipulations, will have become considerably enlarged. The prostate, which now lies free in the bladder, is withdrawn by strong forceps through the suprapubic wound. There is, as a rule, very little bleeding from the operation. The cavity left by the removal of the prostate disappears owing to the inherent elasticity of the sheath, the contractility of the surrounding muscles, and the pressure of the pelvic structures. The contractility of the cavity will be greatly facilitated by pressing its opposing surfaces together by the points of the fingers in the bladder and rectum. Irrigation of the bladder by hot lotion through a catheter and out by the suprapubic wound will help to check the hemorrhage, but if irrigation is continued for more than two minutes it increases the bleeding. The bladder having been cleared of clots, and while the irrigation is still proceeding, a rubber drainage-tube seven-eighths of an inch in diameter and provided with large lateral openings, and about 5 inches long, is introduced into the bladder for a distance of no more than one inch. Nothing is introduced into the prostatic cavity, the object being to facilitate its contraction. The edges of the parietes are now brought together around the tube by silkworm-gut sutures, some of which should pass deeply through the recti muscles, leaving room for a small prevesical gauze wick. No sutures are inserted into the bladder. Before withdrawing the catheter and applying the dressings the bladder is once more irrigated to ascertain that the drainage is free. During the twenty-four hours after the operation there will generally be some clots lying in the drainage-tubes; these should be removed by long forceps at each dressing. The bladder should be irrigated daily, using a long glass nozzle which is introduced into the drainage-tube, care being taken not to cause pressure in the bladder which might disturb the prostatic cavity. The tube is removed in from three to five days. Irrigation of the bladder must be continued once or twice daily, the fluid being allowed to flow out through the suprapubic wound around the nozzle until the fistula contracts, when the irrigation is accomplished by ordinarily filling the bladder and withdrawing the nozzle, thus allowing the escape of fluid. As the case advances more and more pressure on the bladder may be employed. After nine days irrigation of the bladder by means of hydraulic pressure through the urethra may be employed, but when natural urination is established no more irrigations are used. The management of the bowels is of the utmost importance. For three or four days previous to the operation they should be moved freely once daily by means of laxative pills given at night and a mild saline given in the morning, and on the morning of the operation by means of an enema. The bowels should then be left undisturbed for two or three days, and they should then be moved freely by castor oil; after this they should be moved gently once a day. Secondary hemorrhage has occurred in a few instances, and should it persist and give rise to pain and spasm from the accumulation of clots in the bladder, no time should be lost in reopening the suprapubic wound and inserting a large drainage-tube for three days to relieve the pressure on the walls of the prostatic cavity."

In speaking of the cases which are suitable for suprapubic prostatectomy, Freyer says: "In patients in the earlier stages of the malady in whom not more than an ounce or two is found on introducing the catheter, it is inadvisable to attempt the removal of the prostate because the enlargement of the organ will not have sufficiently advanced to render it prominent in the bladder or to define adequately the lines of cleavage between the true capsule of the prostate and its enveloping sheath. When we have to deal with adenomatous enlargements of smaller dimensions, say less than 1½ ounces in weight, the greatest difficulties present themselves as to the possibility of their enucleation entire being practicable. If on cystoscopic examination we find that there is a well-defined outgrowth of one lobe or marked prominence of both lobes in the bladder, the case may be pronounced to be permitting of the enucleation of the growth entire. Prostates weighing from 2 to 6 ounces are most easily and rapidly enucleated, but prostates of larger size can be similarly dealt with, though those attaining to enormous dimensions present difficulty in removing them, mainly owing to their being impacted beneath the pubic arch, and to the difficulty experienced in reaching with the finger the distal portions of the growth." Freyer then detailed several cases which were extremely difficult and which required about half an hour for the enucleation. Freyer has made a number of consecutive reports of cases in the "British Medical Journal."

The following table, which has been compiled from them, shows a gradual improvement in the mortality, viz.:

In	the	first	45	cases	there	were	5	deaths,	a mortality of	11 per cent.
"	"	110	"	"	"	10	"	"	10	"
"	"	170	"	"	"	16	"	"	9.4	"
"	"	203	"	"	"	16	"	"	8	"
"	"	322	"	"	"	25	"	"	7.8	"
"	last	119	"	"	"	9	"	"	7.5	"

Deaver has been one of the most enthusiastic supporters of Freyer in this country, but the operation as he performs it differs very materially from "Freyer's" operation, *e. g.:* The incision is much longer, so that retractors may be inserted into the bladder to give a view of the prostate; an incision over a lateral lobe is usually made with scissors; "when the prostate is large a second incision must be made over the other lateral lobe"; if a pedunculated median lobe is present it is removed, and "if no other urethral obstruction exists the operation may be terminated, and the bulk of the prostate be left untouched"; in case of persistent hemorrhage the cavity is packed with gauze and the margins of the mucous membrane around the cavity sutured over the packing with catgut; a drainage-tube about three-eighths of an inch in diameter and about two feet long is used; the bladder is irrigated and a "sound passed once a week for some months after the operation" to prevent stricture. Deaver says that the ejaculatory ducts are almost always torn loose from the urethra, and that the urethra is generally removed in its entirety with the prostate, being torn across at the membranous urethra.

Perineal Prostatectomy.—The earliest operations for the relief of retention of urine due to prostatic hypertrophy were done through the perineum, references to division of the vesical neck through the perineum being present in several of the early medical writings. The work was apparently lost sight of, and it was not until after Massa in the sixteenth century "rediscovered" the prostate that Riolanus again incised the vesical neck with successful results. Covillard, in 1639, was apparently the first to remove a hypertrophied middle lobe by tearing it away with forceps after perineal lithotomy, and although he operated upon two cases, we can find no further references to similar operations until two centuries later. Sir William Fergusson in 1848 exhibited specimens of hypertrophied prostates which he had enucleated through the perineum after removal of a calculus. In 1870 he again refers to this work, and mentions one case in which he had no difficulty in enucleating the lower portion of the prostate in a man eighty years of age, and remarks: "When the surgeon is called upon to relieve his patient from stone and finds an enlarged prostate, why should he not take away a superfluous portion of the prostate at the same time?" In 1866 Küchler formulated the first systematic technic for the radical removal of the prostate through the perineum, but his operations were done only in the cadaver.

In 1867 Billroth, following Küchler's advice, performed the first intentional prostatectomy upon two patients suffering from prostatic enlargement. The operation, however, seems not to have been a complete enucleation of all the lobes of the prostate. In 1873 Gouley, of New York, advocated systematic enucleation of the lateral lobes, and an excision of the median lobe through the perineum, but we have no record of its performance until Goodfellow, in 1891, without knowledge of the work of his predecessors, carried out the same procedure and in successive publications reported many successful cases. Goodfellow therefore deserves the credit of being the first to make a success of prostatectomy, and his operation, which is still employed today, is described by himself as follows: "With the patient in the ordinary lithotomy position, the legs held by an assistant, the bladder being empty or full, as the case may be, the lithotomy staff is introduced, the legs elevated somewhat, a median incision from the base of the scrotum to the margin of the anus is made [through the bulbous] and carried to the membranous urethra, which is entered with a straight lithotomy knife and the opening extended into the bladder. The finger is then introduced into the bladder, the staff removed, and the moderate flexion of the legs on the abdomen and thorax increased to as great an extent as possible. Then with the hand on the hypogastrium the bladder is depressed and the enucleation, beginning at the beak of the prostate below and working upward next to the bladder, or from above on either side downward, is carried on, the time consumed for complete enucleation rarely being over five or ten minutes. The gland may be removed entirely or lobe by lobe. Part or all of the prostatic urethra is removed with the gland." At a later date he says: "I do not find it necessary to use a knife to enter the urethra or bladder. After getting to the urethra I am able to open it and get into the bladder

by a boring movement, then, having cut through the commissure, I enucleate from above, and not from below as formerly."

In 1894 Nicoll, and in 1896 Alexander, advocated the use of a suprapubic intravesical incision through which the prostate could be pushed toward the perineum, where it was enucleated. In 1899 Bryson advised that the incision be made only through the abdominal muscles and that the prostate be pushed downward by prevesical pressure.

In order to obviate the suprapubic incision numerous instruments have been devised to draw the prostate down into the perineal wound, among which may be mentioned the rubber balloon of Syms, the désenclaveurs of Delbet, Albarran, dePezzer, and Legueu (1901 and 1902), and the tractors of Young and Lydston (1903). We have not space to go into the details of the various methods which have been proposed. The operation as employed by Syms and Bryson was similar to that of Goodfellow, a blind enucleation of as much of the prostate as possible through the perineum with no attempt to avoid the external sphincter, the urethra, or the ejaculatory ducts. The French school, represented by Proust and Albarran, exposed the prostate through a transverse perineal incision which extended through the levator ani muscles, made an extensive dissection, opened the prostate upon a "désenclaveur," which was then removed, and excised the prostate piecemeal with scissors, the ejaculatory ducts being destroyed and ligated and the urethra only partially preserved.

The operation of conservative perineal prostatectomy which was presented by the writer in the "Journal of the American Medical Association," October 24, 1903, was developed quite independently and without knowledge of the work of the French school, to which, however, it bore resemblance, but only superficially. The tractor, which I have since found to be similar to that of dePezzer, is much more powerful and is used to draw down the prostate and to facilitate the enucleation of the three lobes of the prostate, whereas the French instruments were habitually removed as soon as the prostatic urethra had been opened and before the enucleation of the prostatic lobes began. As Proust and Albarran have since discarded their operations, I will only describe the technic which I still employ.

Technic of the Operation of Conservative Perineal Prostatectomy.—*Position of the Patient.*—The exaggerated dorsal position of the patient is the most satisfactory, and the perineal board devised by Halsted is admirably suited for this purpose. The perineum should be so elevated that it is almost parallel with the floor, thus allowing excellent retraction of the rectum and splendid exposure of the posterior surface of the prostate. After placing the patient upon the table, before elevating the thighs, a No. 24 F. sound should be inserted into the posterior urethra, to be used subsequently as a guide for urethrotomy. If the operator waits until the patient is placed in the urethrotomy position, he will frequently find it difficult to introduce the sound through the triangular ligament.

Cutaneous Incision.—The inverted V cutaneous incision unquestiona-

bly gives a much better exposure than a median incision. The apex should be just over the posterior part of the bulb, about two inches in front of the anus, and the lateral branches directed outward and backward parallel to the ischiopubic ramus, each about two inches in length, as shown in Fig. 229. The incisions are carried through the skin, fat, and superficial fascia, and then by blunt dissection with the handle of the scalpel and the index-finger of the left hand the space to each side of the central tendon is opened up. In this way it is very simple to open up by blunt dissection very quickly a space on each side reaching as far as the triangular ligament. In so doing the levator ani is pushed backward and outward on each side and the transversus perinei muscles are pushed forward.

Exposure of the Membranous Urethra.—The bifid retractor is inserted as shown in Fig. 230; traction upon this instrument gives an excellent exposure of the narrow band of central muscle and tendon and greatly facilitates the division close to the bulb without injuring this hemorrhagic structure. After the central tendon has been completely divided and the posterior surface of the bulb freed, it is well to insert a retractor, by which the bulb is drawn upward and a better view obtained of the recto-urethralis muscle, which lies between the two branches of the levator ani and covers the membranous urethra, toward which it draws the anterior wall of the rectum. In dividing the recto-urethralis muscle care should be taken not to injure the rectum, which is often drawn forward so that it lies almost in front of the membranous urethra. It nearly always covers the apex of the prostate. As soon as the recto-urethralis has been thoroughly divided it is easy by blunt dissection to push the rectum backward and thus obtain a good view of the membranous urethra, the bulb being drawn forward along with the muscular structures of the triangular ligament. The membranous urethra is then opened upon the sound (Fig. 231) and the edges picked up with ordinary clamps, being sure to secure the mucous membrane. A sound is then inserted into the bladder through

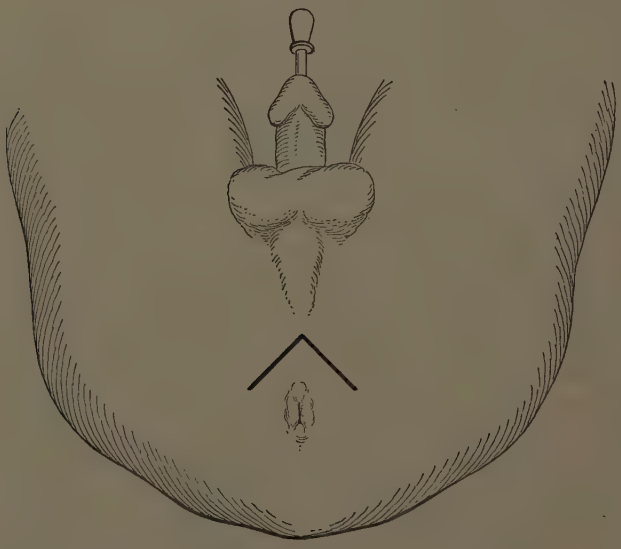

FIG. 229.—THE INVERTED V CUTANEOUS INCISION.

the urethral wound (an assistant having withdrawn the sound from

FIG. 230. -SHOWING BIFID RETRACTOR, EXPOSING AND MAKING TENSION ON THE CENTRAL TENDON.

FIG. 231.—OPENING OF URETHRA ON SOUND, PREPARATORY TO INTRODUCTION OF TRACTOR.

the anterior urethra), to open up the way for the prostatic tractor,

which is then inserted into the bladder through the perineal urethrotomy wound. Owing to the rectangular shape of this instrument (Fig. 232) it is sometimes difficult to insert. Sometimes it is well to begin its introduction with the beak turned backward, and then to rotate the instrument 180 degrees before carrying it into the bladder. After the instrument has penetrated into the prostatic urethra it is generally advisable to remove the anterior bulb retractor, and thus allow the shaft of the tractor to be carried farther forward. As a rule, little difficulty is experienced in inserting the tractor if one has been careful to secure the

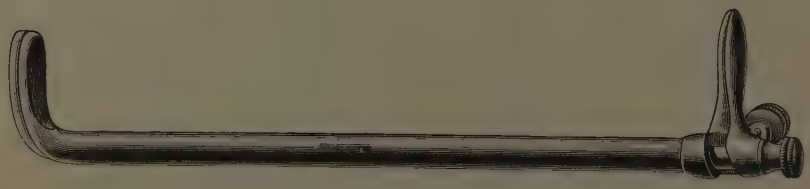

FIG. 232.—YOUNG'S PROSTATIC TRACTOR CLOSED.

edges of the mucosa of the membranous urethra. After reaching the bladder the blades of the tractor are opened out by means of the external handles (Fig. 233), and after being fixed in this position by means of a set screw, traction is made upon the prostate, and the further separation of the rectum from the posterior surface of the prostate made. After dividing the recto-urethralis muscle and exposing the apex of the prostate one generally finds it necessary to use the knife to divide a layer of fibrous tissue which lies behind the posterior surface of the prostate. After this (the posterior layer of Denonvilliers' fascia) has been divided

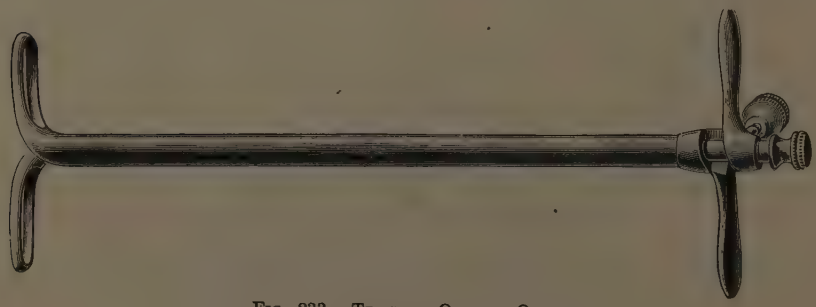

FIG. 233.—TRACTOR OPENED OUT.

the rectum can be more easily pushed backward, and one enters, generally with ease, into the space between the two layers of Denonvilliers' fascia, and the smooth glistening surface of the prostate is exposed. When this layer is properly exposed, no difficulty whatever is experienced in rapidly freeing the entire posterior surface of the prostate and seminal vesicles, a good view of which is obtained at once by the insertion of a broad angular retractor, such as is shown in Fig. 234.

Incision of Capsule.—Lateral retractors are so placed that with posterior retractors drawing the rectum backward and the prostatic tractor

drawing the gland outward a splendid exposure of the posterior surface of the prostate is obtained. An incision is then made through the capsule on each side of the median line for almost the entire length of the posterior surface and about 1.5 cm. deep. These incisions are about 1.8 cm. distant behind and 1.5 cm. distant in front, as shown in Fig. 235. The bridge of tissue which lies between them contains the ejaculatory ducts and the floor of the urethra. The advantage of these deep incisions is that it brings us to the side of the urethra, where separation from the internal surface of the prostatic lobes can be easily begun.

Enucleation of the Lateral Lobes.—This is begun with a blunt dissector, the capsule being first elevated from the posterior and external surface of the lateral lobes on each side. In a similar way the urethra and external surfaces of the lateral lobes should be separated. At the apex of each lateral lobe firm adhesions to the capsule are present, and it is advisable to divide these with scissors. It is then best to insert the index-finger and continue the enucleation first along the anterior surface of the prostate until the bladder is reached, and then laterally and internally until finally the entire lateral lobes are enucleated. During this procedure the tractor is of great assistance, not only in drawing down the prostate, but the shaft shows the position of the urethra and the intravesical blade and the position of the vesical mucosa, so that the operator is able to avoid tearing into both these structures. Occasionally it is advisable to grasp the lobe during the process of enucleation with lobe forceps (Fig. 235) which are entrusted to an assistant who makes traction upon them. In enucleating the lateral lobes it is important to leave nothing behind, and particular care should be taken, especially anteriorly, as it is an easy matter to overlook a portion of the gland in this region.

FIG. 234.—POSTERIOR RETRACTOR.

The Enucleation of the Middle Lobe.—After the lateral lobes have been shelled out attention should be directed to the median portion of the prostate. If a definite rounded lobe is present (and the previous cystoscopic examination, which should always be made, will tell what is to be expected), it is generally possible to engage it with one blade of the tractor in the bladder, and by rotation and traction to deliver it into one of the lateral cavities, sometimes with the assistance of an index-finger, as shown in Fig. 236. In this position the lobe can generally be grappled with a lobe forceps and enucleated without injuring the ejaculatory ducts behind it or the vesical mucous membrane covering it. Occasionally small tears are made into the urethra, but these are of no consequence. Very little difficulty is thus experienced in shelling out median lobes of considerable size (in several cases they were three inches in diameter). In many instances, however, the median enlargement is in the shape of a trans-

verse bar which cannot be enucleated effectively with the blade of the tractor in the bladder. In such cases it is often wise to pick up this portion of the prostate with a sharp hook through one of the lateral cavities, as shown in Fig. 237, and then to begin to separate first from the ejaculatory ducts which lie behind it and then from the urethra in front of it. After being partly freed it can be grappled with small hemorrhoid clamps and removed with little difficulty, generally by blunt dissection, but sometimes with the aid of scissors. Removal of the median lobe leaves a cavity communicating with two lateral cavities in front of the ejaculatory ducts, and behind the urethra.

Insertion of the Finger into the Bladder.—It is next advisable to examine the condition of the vesical orifice and sphincter with the finger, as it is

Fig. 235.—Enucleation of Lobes. Forceps in Position.

not infrequent to find a sclerotic band around the vesical orifice. As a rule, a linear tear has been made along one of the lateral walls of the urethra, and through this the finger can be introduced into the bladder. It is often found to be tightly gripped, sometimes by a firm fibrous band which requires considerable force before it will give way sufficiently to allow the finger to enter the bladder. In such cases it is well to thoroughly dilate the vesical orifice with the finger and with forceps. A careful examination should be made as to the conditions around the orifice, first to see whether the median portion of the prostate has been completely removed, whether a bar or any valve-like structure remains to lead to subsequent obstruction to urination. The intravesical portions of the lateral lobes should then be examined, and if any portion remains it should be removed, using the finger as a tractor to draw forward and

cause it to present the remaining portion. Care of this sort prevents leaving any portion of the gland which might in the future give trouble.

FIG. 236.—SHOWING TECHNIC OF DELIVERY OF MIDDLE LOBE INTO CAVITY OF LEFT LATERAL LOBE.

It is also well to sweep the finger through the bladder cavity, searching for interesting conditions, calculi, diverticula, etc.

Removal of Calculus.—If a calculus has been shown to be present by the cystoscope, or if its presence has been suspected but not demonstrated, it is well to insert a stone forceps after thorough dilatation of the vesical orifice, and with the finger as described above. When a calculus is caught, it is generally easy to remove it through a dilated urethral orifice. If, however, it is too large, it will be necessary to divide one lateral wall of the urethra, and possibly a small portion of the structures surrounding the vesical orifice, as shown in Fig. 238. Through such an incision with additional dilatation it is easy to remove a calculus two inches in diameter, and if the vesical mucosa be divided upon the anterior surface of the calculus (traction being maintained with the stone forceps), calculi of very great size can be removed without much difficulty. In the case of small stones it is not necessary to place any sutures after the removal of the calculus. In cases where it has been necessary to divide sphincteric structures or very greatly dilate the prostatic orifice it seems advisable to reunite these structures with one or two sutures of catgut, which can be placed without much difficulty. A "gall-bladder scoop" is an excellent instrument with which to search the bladder for small calculi, fragments, etc.

FIG. 237.—SHOWING REMOVAL OF A FIBROUS MEDIAN BAR.

Closure.—After the operator has made certain that the lateral and median lobes have been thoroughly removed, that the vesical orifice is well dilated, and that no calculi remain, double drainage of the bladder through the prostatic urethra should be provided. For this purpose it is best to use two large catheters, the eyes of which have been enlarged and their ends sewed together after being obliquely divided, so that they form a common point and can thus be easily introduced. One of the catheters is at once connected up with a fountain syringe and the bladder thoroughly washed clean of blood. One or both of the catheters may become plugged with clots, but by "stripping" the catheter strong suction is obtained and the clots easily evacuated. The lateral cavities are then carefully packed with gauze, a single three-inch strip being used on each side and care being taken to pack only the interior of the prostatic capsule, the ends of the gauze being brought out along with the rubber tubes. The catheters and gauze wicks are then drawn forward by a retractor while an examination is made of the anterior wall of the rectum; the index-finger of the right hand, which has been covered with a rubber glove, being inserted into the rectum and a digital examination of the rectal wall thus thoroughly made. If the operation has been carefully performed, no injury to the rectal wall will be discov-

ered, but occasionally in the earlier operations I found that the rectal wall has been injured in separating it from the apex of the prostate. In such cases it is advisable at once to close the rent with two or three layers of sutures, the deep layer being of fine silk, the others of catgut, and to finally reinforce by sutures drawing together the levator ani muscles over the rectal wound. Unless a careful examination of the rectal wall is made, even a small tear is almost certain to result in a recto-urethral fistula.

FIG. 238.—DIVISION OF LATERAL WALL OF URETHRA TO ALLOW EXTRACTION OF LARGE CALCULUS THROUGH LEFT LATERAL CAVITY.

It is extremely important to draw the levator ani muscles together in front of the rectum in order to restore them to their normal position, and thus give the rectum the support which they normally furnish. This can be done by means of a single suture of catgut, as shown in Fig. 239. The support which this firm muscular buttress furnishes to the rectum is of great importance and should never be neglected. The skin is then closed with interrupted sutures of catgut, about four on each side, leaving the gauze and tube drainage to emerge from the apex of the wound, to which the tubes are fastened by suture.

Continuous Irrigation.—Continuous irrigation of the bladder (in one

tube and out the other) is begun as soon as the drainage-tubes have been inserted and continued until the wound is sutured. If the fluid escaping is almost free from blood, the irrigation is discontinued and both tubes clamped, leaving the bladder more or less full of fluid (so as to prevent early clotting), and the patient at once returned to the ward, where continuous irrigation is again begun as soon as he has been placed in bed. I employ an iron stand to support a porcelain tank holding two gallons, and filled with salt solution at a temperature of about 125° F. This is connected by means of a rubber tube with one of the drainage-tubes, while the other is connected with a tube leading into the receptacle

FIG. 239.—APPROXIMATION OF LEVATOR ANI MUSCLES WITH SINGLE SUTURE OF CATGUT.

beneath the bed. At first a fairly rapid irrigation of the bladder is maintained, but as the amount of blood diminishes the inflow can be gradually made less and less by simply clamping off more of the tube leading from the tank (a simple hemostat being used). Several hours later if the fluid comes away perfectly clear the irrigation may be discontinued. The replenishment of the tank with sterile salt solution is not a difficult matter. For this purpose several kettles are made use of, the salt solution being thus sterilized by boiling, but not poured into the receptacle until it is cooled off or has been mixed with a cold solution. If at any time one of the tubes becomes plugged with a clot, proper drainage can be generally established by reversing the irrigation. If this does not succeed, the

clot can often be drawn out by suction obtained by stripping the catheter as above described. If, however, care is taken to provide sufficiently free irrigation while the blood is at all abundant, no such difficulty should arise. When a single drainage-tube is employed, although of large size, it almost always becomes plugged with blood, and in my earlier cases great difficulty was experienced in evacuating blood from the bladder and restoring drainage until the method of double drainage with continuous irrigation was adopted.

Infusions.—It is extremely important to keep up vascular tension after the operation in all of the cases, in order to prevent operative shock and suppression of urine. For this purpose it is wise to have the patient drink an abundance of water up to the time of the operation, and if his condition is at all serious to begin a submammary saline infusion when he is placed upon the table. If these precautions are taken, operative shock should never occur, and, in fact, in two hundred and thirty cases it has been present only three times, and in all of these cases spinal anesthesia had been employed. The exaggerated dorsal position has, however, much to do with the maintenance of good arterial tension, which usually remains strong even in cases where considerable blood is lost. The submammary infusion, if not given on the table, is always given on the return of the patient to the ward, about 700 c.c. being the amount received by the patient. He is urged to drink water in abundance, at least two liters daily, and if on account of nausea or any other reason he is unable to take enough water by mouth, it is given by rectum or by a submammary infusion every day or two. The use of the small rubber catheter connected with a very slightly elevated supply of salt solution has been found most satisfactory in introducing salt solution into the rectum. The catheter has given very little discomfort and the patient has generally absorbed a large amount of fluid without expelling it.

Management of the Wound.—The gauze packing should be removed about eighteen hours after the operation. Before this is done it is generally wise to begin anew the continuous irrigation, which should be allowed to flow while the gauze is removed and several hours later until all bleeding has ceased. Unless this is done fresh hemorrhage, which usually occurs with removal of the gauze, may lead to obstruction of the urethra and bladder. The tubes should usually be removed four or five hours after extraction of the gauze, and no further packing or drainage should be necessary. For several days most of the urine escapes through the perineal fistula, and the dressings should be changed sufficiently often to keep the patient comfortable, the wound being washed with a boric solution several times daily to prevent infection. It is remarkable, however, that the sutured portions of the wound seldom break down even when the urine escaping through the open wound is of a very foul character. In a short time more and more urine will begin to flow through the anterior urethra, and the perineal fistula will finally heal. This occurs generally within three weeks, sometimes as soon as five days, and often within two weeks.

Outdoor Treatment.—It is extremely important that these patients

should be out of bed and out of doors as soon as possible, and it is generally feasible to put them into a wheel-chair on the second day after the operation. Under this treatment their vigor returns so rapidly that they are almost always walking before the end of the first week. Those who are too sick to be removed from bed should be propped up very soon after the operation and frequently turned from side to side so as to prevent hypostatic congestion of the lungs. Massage should also be given so as to assist the circulation and improve the bodily strength. Good nourishing food should be given very soon after the operation, even in cases with poor renal function; prolonged liquid diet often does more harm than good. The use of water as above described, however, is of very great importance, especially in the latter class of cases. If the patient is not nauseated, urotropin should be used in moderate amount, 10 to 25 grains daily, and in cases in which the bladder is sterile before operation even larger amounts may be used and great care otherwise taken to prevent vesical infection.

Instrumentation.—No instrumentation is necessary. I have never seen a definite case of stricture of the urethra as a result of the operation, and I never found it necessary to pass sounds at stated intervals after the operation. There is no reason why a small linear incision in the membranous urethra should result in stricture, and in fact it does not, and the passage of sounds, which is employed by some operators, may be necessary after some procedures, but not after this.

Before the patient leaves your care it is usually wise to pass a small silver catheter to determine whether any residual urine is present, the capacity of the bladder, the accidental presence of calculus, stricture, etc. In the majority of cases no residual urine will be found, but in some cases where the vesical tonicity was poor and the amount of the residual urine great, a certain amount of residual urine may still be present. As a rule, this will diminish rapidly with time, and treatment seems to have very little effect upon it.

Stay in the Hospital.—It is usually unnecessary to keep the patient in the hospital any longer than about three weeks, and in some instances the period has been much shorter, especially where the fistula has healed early. Tardy closure of the fistula often causes the patient to stay longer than necessary, as the slight treatment required can usually be continued as well at home as elsewhere. The bi-weekly application of a stick of nitrate of silver is usually all that is necessary to cause the fistula to heal, but occasionally the use of a small curet is necessary.

Results of Operation.—In order to arrive at the proper understanding of the operative results I shall quote at length from an extensive study of one hundred and forty-five cases which I made one year ago in the "Johns Hopkins Hospital Reports," vol. xiv.

Operative shock occurred in only three cases; all of these were performed under spinal anesthesia, all were very weak subjects, and aged respectively seventy-five, seventy-six, and eighty-two years. In all these cases an immediate transfusion was performed and all recovered. In view of the fact that a number of patients just as old and as weak as

these were operated upon by ether without shock, I am inclined to think that the spinal anesthesia with cocain was responsible for the shock.

Vesical calculi were present and removed in twenty-five cases and added very little to the difficulty of the operation. It was clearly demonstrated that it was much simpler to remove the calculi after the removal of the prostatic lobes than to resort to preliminary litholapaxy. Several calculi of very large size were removed without difficulty and the post-operative results were good.

Since the plan of removing the gauze and tubes on the day after the operation and of getting the patients out of bed within the first two or three days has been carried out the length of convalescence has been markedly reduced. The urine has begun to flow through the anterior urethra at an earlier date and the closure of the fistula has been hastened. In a number of cases no urine has escaped through the perineum after the first week, but the average time has been about fourteen days. Epididymitis occurred in twenty cases; suppuration and partial breaking down of the wound in six cases; post-operative hemorrhage in four cases, in all of which, with one exception, it was rapidly controlled by repacking the wound. I have yet to see a single case of definite stricture of the urethra following the operation, and it does not seem possible that the small linear incision in the membranous urethra could ever produce one.

The average length of time in the hospital has been about three weeks. In only five patients was there more than 50 c.c. residual urine on the discharge of the patient from the hospital; all but one of these had a greatly distended flabby bladder before the operation and the vesical tonicity had not fully returned. Incontinence of urine disappeared with remarkable rapidity. In four cases in which no drainage-tubes were used perfect control was present from the time of the operation. In sixteen cases interval urination was established between the third and eighth day. In other cases the sphincter was usually weak for a longer period, but in only six cases was this at all prolonged. Only two cases of definite incontinence of urine persisting after the operation have been met with, and these patients now show definite signs of tabes.

The sexual powers have been preserved in almost all cases. In a few the erections were slow in returning and satisfactory intercourse did not return for a year, and in a very few cases puissance was lost. In five cases in which erections had been present for prolonged periods there was a complete restoration after the operation.

All but four cases were apparently completely cured of obstruction to urination by the operation. In three of these cases the patients have been markedly benefited by the operation, but in one case the retention of urine is almost complete, and the catheter is necessary. The cystoscope shows in these cases that the median enlargement was not completely removed.

A pin-point fistula persisted in four cases. In none of these, however, did it give more than slight discomfort. Recto-urethral fistula were present in two cases. Since we have adopted the plan of approximating the levator ani muscles there has been no case of recto-urethral fistula in over one hundred consecutive operations.

Mortality.—I have now (December 1, 1907) had one hundred and ten consecutive cases of perineal prostatectomy without a death, and the total is now two hundred and thirty-seven cases with seven deaths, a mortality of 2.9 per cent. In none of the cases was the death directly in consequence of the operation, as shown by the fact that one occurred during the fifth week, two during the fourth week, three during the third week, and only one during the second week after the operation. The cause of death was pulmonary thrombosis, one case; hypostatic congestion of the lungs, two cases; pneumonia, one case; pyonephrosis, two cases; secondary hemorrhage from a vesical ulcer on the eighth day after the operation, one case. All but one of these patients were in a very weak condition before the operation, and two were over eighty years of age, one eighty-seven. Two were markedly uremic and were operated upon as a last resort.

In the first series of one hundred and sixty-three cases eighteen were described as being in a very weak condition, and in seven marked emphysema of the lungs was present. Marked arteriosclerosis was present in six cases, associated with angina pectoris in one case and hemiplegia in another. In twenty-two cases heart murmurs and other evidences of old endocarditis were present, and in eight cases the heart was enlarged although no murmurs were heard. Pyonephrosis was present in eight cases, and in ten cases granular casts were found in the urine.

In the last series of one hundred and forty-six consecutive cases there has been only one death, all the other patients having gone home. The ages of these patients were as follows:

Under 50 years of age				10	cases.
50 to 59	"	"	"	29	"
60 " 69	"	"	"	57	"
70 " 74	"	"	"	23	"
75 " 79	"	"	"	20	"
80 " 84	"	"	"	6	"
89	"	"	"	1	case.

Many of these patients were in far from good condition before the operation. In nine cases cardiac murmurs of marked degree were present and in eight the heart was enlarged. Several cases showed marked evidences of myocarditis and in others a history of severe attacks of angina pectoris was present. One patient suffered with double pulmonary tuberculosis; in several cases unmistakable evidences of severe renal infection were present, and in four of these the patients were very uremic when admitted to the hospital. In a recent case the residual urine was 2500 c.c., and for two weeks before operation the patient was desperately ill with hiccough, nausea, vomiting, and other signs of uremia. At the end of three weeks, however, he was operated upon and has left the hospital entirely well. The single fatal result was in a man sixty-six years of age who gave a history of intermittent attacks of hiccup, nausea, and vomiting, during several of which he had almost succumbed. He had never been catheterized and there was constant dribbling of urine with a

residual of 800 c.c. During four days in which he was treated by frequent catheterization he seemed to improve and the operation was therefore carried out, but immediately after the operation he became nauseated and continued to have hiccup, nausea, and vomiting for ten days, at the end of which time he died. Autopsy showed pyonephrosis, marked dilatation of the kidneys and ureters, dilatation of the stomach, transposition of the liver, and other abnormalities. Despite the apparently hopeless condition shown at autopsy I believe that had I carried out preliminary drainage of the bladder through a catheter for a longer period and used infusions more frequently after operation he could have been cured. Up to the time of his death there had been one hundred and twenty-eight consecutive cases without a death, which is sufficient to show that the operation is practically free from danger and produces little if any shock.

There have now (April 26, 1908) been two hundred and seventy-three cases with eight deaths, a mortality of 2.8 per cent. Seven of these deaths occurred among the first one hundred and twenty-seven cases. Among the last one hundred and forty-six cases there has been, as stated above, only one death.

No effort whatever has been made to select cases in order to produce a record, and during the past two years not more than two or three patients have been refused operation, and these have died in a very short time from a rapid termination of the desperate condition in which they were admitted to the hospital.

The almost entire absence of mortality during the past three years I attribute to the free use of water before and after operation, the ability to prevent hemorrhage by intracapsular packing, the dependent drainage which prevents infection, and the promptness with which the patient is gotten out of bed.

These statistics, I believe, prove conclusively that perineal prostatectomy is not only the safest operative procedure, but indeed much safer than the use of the catheter. There are a certain fairly large number of cases in which the perineal method is alone applicable. These are cases of small hypertrophy which do not project into the bladder (and which Freyer considers inoperable); cases with marked fibrosis or severe chronic prostatitis and therefore not enucleable; and cases with cancer present. Certain cases of severe chronic prostatitis can be quickly cured by perineal prostatectomy. When the induration is great, cancer should generally be suspected, and an exploratory operation carried out. The good exposure furnished through the perineum makes it possible to examine sections of the prostate, and to perform either a conservative or a radical operation as indicated by the findings. With a mortality practically *nil*, perineal prostatectomy seems unquestionably much safer than the Bottini operation and than suprapubic prostatectomy.

Cancer of the Prostate.—Up to 1850 very little was known concerning cancer of the prostate, and Gross, of Philadelphia, was one of the first to furnish definite information of the disease. The most important of all the papers for many years was that of Thompson, who in 1881

collected twelve cases, and called attention to the importance of cancer of the prostate. Since then a number of important papers have appeared, but as a whole the subject has been lost sight of in the mass of literature upon prostatic hypertrophy. The most important papers of recent date are by Guyon, von Recklinghausen, Pasteau, Albarran and Hallé, Motz, Kaufmann, Hawley, Young, Pousson, Montfort, Hallopeau, and Motz and Majewski.

Frequency.—Until very recently carcinoma of the prostate has been considered comparatively rare. In a recent report Wallace stated that among sixty-five cases operated upon suprapubically, nine were found to be carcinoma (14 per cent.). In the five years between October, 1902, and October, 1907, I have seen two hundred and fifty cases of benign prostatic hypertrophy and sixty-eight cases of carcinoma of the prostate, or 21 per cent. of all. The proportion between cancer and hypertrophy was therefore over 1 to 4. Of the two hundred and fifty cases of hypertrophy, I have personally operated upon two hundred and thirty, and nearly all of the remaining twenty were operated upon by assistants. In only five cases did the disease prove to be malignant when a diagnosis of benign hypertrophy was made before operation. In the light of our recent studies, however, four of these cases should have been easily recognized, on account of the stony hardness of the induration present. Most of the cancer cases arrived when the disease was well advanced and radical operation out of the question, but four were early, and of these, two show no signs or symptoms of recurrence now, two and one half years after the operation of radical excision. I am aware that my figures attribute to cancer a more frequent occurrence than any others in the literature, but I believe they represent the true condition; and this does not include cases of "epithelioma adenoid" of Albarran, by which he was able to show that 14 per cent. of the supposed benign hypertrophy in the Musée Guyon contained malignant changes. If I include cases in which the glandular epithelium showed characteristics which Albarran accepted as evidence of malignancy, the proportion of cancer would probably reach 30 per cent.

The etiology of cancer of the prostate is as obscure as that of cancer in general. It appears at the same age as hypertrophy of the prostate—after forty years, and most frequently between sixty and seventy years of age. In my cases there were very few clinical cases which suggested that possibly the disease had begun as a benign hypertrophy and had subsequently become malignant, and the almost total absence of the large intravesical lateral lobe enlargements which are so common in hypertrophy confirms this view. The fact, however, that in a careful study of one hundred and twenty specimens removed by prostatectomy only one was found in which an area of malignancy was present in an otherwise benign adenomatous hypertrophy shows, I believe, that the theory of frequent "malignant degeneration" in previously benign hypertrophies of the prostate is not tenable.

Pathology.—Albarran has recognized two forms, the circumscribed and the diffuse carcinoma of the prostate. By the circumscribed is meant

that in which the cancer has not progressed beyond the limits of the prostatic capsule, and of this he says there are three varieties: First, those in which one or more nodules of cancer appear in an otherwise benign hypertrophy; second, one in which the prostate is not augmented in volume although the neoplasm infiltrates the whole gland; and third, one in which the prostate is enlarged and irregular and completely invaded. The diffuse carcinomata are those in which the seminal vesicles, bladder, rectum, or other adjacent structures are invaded by cancer which has passed beyond the limits of the prostate. This form has been described under the name of "prostato-pelvic carcinosis" by Guyon. Albarran and Hallé are of the opinion that the development of carcinoma in the lobules of an apparently benign hypertrophy is not uncommon, and claim to have discovered fourteen cases in one hundred specimens examined. In most of these cases the macroscopic appearance did not suggest malignancy, and the picture was that of ordinary benign hypertrophy, but with the microscope certain lobules were found in which the glandular epithelium presented a wild growth and certain involution changes which they thought were sufficient to represent malignancy. For this condition they proposed the term "epithelioma adenoid."

In a careful study of one hundred and twenty specimens of prostates removed by perineal prostatectomy, in only one was there found any area suggesting carcinoma. In this case a small nodule about 2 mm. in diameter was noted in an otherwise benign prostatic hypertrophy. The stroma was distinctly infiltrated by the widely growing cells and the diagnosis of carcinoma was very definite. An examination, now four years after the operation, shows no recurrence, and would seem to indicate that the other portions of the prostate had not been invaded. We have not infrequently found areas where active gland proliferation was present, and the papillary projections presented a wild profusion and slight involution changes, but these have been noted in adenomata in other regions, particularly in the breast, and we do not believe necessarily signify malignancy. In the great majority of cases carcinoma is not associated in any way with hypertrophy of the prostate, and all portions of the gland seem to be invaded very early. In all of our cases which came to operation or autopsy this was the case, and in very few of the cases seen clinically did it seem probable that a portion of the prostate was not invaded.

The most common types present a mixture of adenocarcinoma and carcinoma simplex, this form being present in eleven of the eighteen cases in which microscopic examinations were made. Four of these showed a pure adenocarcinoma in some areas and a scirrhus in others. In seven cases the adeno type varied with extensive epithelial infiltration of the stroma. In three cases the neoplasm was a carcinoma simplex, in two cases a tubular form of adenocarcinoma, in two cases a pure adenocarcinoma, and in one case a peculiar medullary type with a very little stroma.

A study of twenty autopsies and operations shows that the invasion is almost always upward into the region of the seminal vesicles. The

posterior capsule of the prostate, which is strongly reinforced by the incorporation of Denonvilliers' fascia, apparently resists invasion for a long time. Cancer cells are found within the ejaculatory ducts, vasa deferentia, and seminal vesicles when the walls of these are intact, evidently having traveled up these ducts. The lymph-spaces, nerve-sheaths, and small blood-vessels are also occasionally seen to be accompanied by cancer cells, and apparently assist in the propagation of the disease in the region beneath the trigone. In many cases the bladder is not invaded at all, and if it is, the invasion is generally from the region of the trigone. In only rare instances does the disease project into the bladder in the shape of intravesical lateral lobules, but occasionally one sees a small, rounded, median bar or lobe carcinomatous in character. Kaufmann found vesical ulceration in only five of one hundred cases. After involving the seminal vesicles the disease most often travels upward and outward along the lateral walls of the pelvis, occasionally producing glandular metastases. Often with extensive involvement no metastatic glands can be found. In one hundred autopsies collected by Kaufmann glandular metastases were present in only twenty-seven. Metastases to the bones, particularly of the spinal column, are not uncommon. The urethra does not usually become ulcerated until late in the disease.

When the cancerous growth passes through the prostatic capsule, it may invade the rectum, the membranous urethra, and even structures anterior to the triangular ligament. In one of my recent cases the corpora cavernosa were infiltrated by cancer nearly up to the glans penis, producing a constant carcinomatous priapism.

Symptomatology.—A careful study of the literature shows very few statistics of value as to the onset, course, and termination of carcinoma of the prostate, and the following analytic study of eighty-seven cases, most of which have been in my private practice, has been prepared. The ages were as follows:

45 years	1	case
Between 50 and 54 years	3	cases
" 55 " 59 "	16	"
" 60 " 64 "	25	"
" 65 " 69 "	19	"
" 70 " 74 "	2	"
" 75 " 79 "	8	"
" 80 " 84 "	3	"
Not stated	1	case
Total	87	cases

These figures correspond to those of Sir Henry Thompson, who in his report of twelve cases in 1860 had one case forty-one years of age; two between forty and fifty; three between fifty and sixty; five between sixty and seventy, and two over seventy, the oldest being seventy-five years of age.

As shown by my statistics, the disease rarely comes on before the age of fifty-five, and 50 per cent. of the cases occur during the decade between sixty and sixty-nine. The onset symptoms were as follows in my series

of eighty-seven cases: Frequency of urination was present in forty-eight cases and difficulty of urination in thirty cases, in eight cases associated with burning in the urethra. Complete retention of urine was the onset symptom in three cases and incontinence in one. In thirteen cases the first symptom was *pain*, located in the penis five times, bladder four times, thigh four times, testicle and groin three times, hip three times, pubes twice, rectum once, legs once, and back twice. The pain was generally slight in character, but in a few cases it was severe, paroxysmal, and very distressing. In severe cases the diagnosis of rheumatism, neuralgia, sciatica, and lumbago had generally been made. Hematuria was the onset symptom in four cases, but it was never of a very severe grade. In one case the first and only symptom during the course of the disease was swelling of the right leg, caused, as examination showed, by extensive pelvic infiltration. In this case urination was normal and the patient suffered no pain, although the prostate was very large. In sixty cases which were studied by Motz the onset symptom was difficulty of urination in thirty-eight; complete retention of urine, eight; hematuria, eight; and neuralgia, five.

Duration.—In all but five of my cases symptoms had been present more than six months, in fourteen cases between six and twelve months, in fifteen cases one year, in twenty-three cases, two years, in eleven cases three years, in eight cases four years, in two cases five years, in one case each six, seven, ten, twelve and twenty years. The patient in whom the symptoms dated back to twenty years had had difficulty of urination and more or less frequent catheterization during that entire period.

Course.—Guyon recognized three forms: (1) those with a rapid course, in which the symptoms may have been present a very short time; (2) those following a subacute course, the disease having been present after the tenth or twelfth month; and (3) those following a very slow course with a duration of two or three and even as long as nine years. In twenty-six carefully studied cases Motz found that 40 per cent of the patients died within seven months after the onset symptoms, seven lived over a year, and six for periods varying from two to ten years. In my cases the course of the disease was generally characterized by gradually increasing difficulty and frequency of urination, residual urine, and intermittent or complete retention of urine. The use of the catheter was generally quite difficult and sometimes impossible. Pain, as a rule, came on early in the disease, most frequently in the urethra, sometimes as a mere burning during urination, but often as a sharp pain, particularly at the end of urination, and radiating to the end of the penis. The occasional association of a terminal hematuria made one suspect vesical calculus. Pain in the rectum, perineum, lumbar region, sacrum, hips, thighs, groins, testicles, or legs came on gradually and progressively in many of the cases and in a good proportion formed the most prominent symptom.

In my eighty-seven cases the symptoms present on admission were as follows: In twenty-six cases there was no frequency and in ten no difficulty of urination. In five cases both these symptoms were slight. In thirty-seven cases there was a very marked frequency of urination, often

at intervals of only a few minutes. Difficulty of urination was marked in twenty-three cases. Twenty-six had complete retention of urine and required the use of the catheter and fifteen had incomplete retention of urine, but employed the catheter from two to six times daily to relieve the difficulty and frequency of urination. Dribbling of urine was present in eight cases and in two cases a suprapubic fistula was present.

Pain was a more or less prominent symptom in all but twenty cases, in which it was either absent or no note was made of it. In six cases the patient complained only of a burning in the urethra, generally during urination. The following table shows the situation and the severity of the pain:

Region.	Slight.	Moderate.	Severe.	Total.
Urethra	4	4	5	13
Penis	2	6	6	14
Perineum	3	1	5	9
Bladder	3	5	9	17
Rectum	4	1	5	10
Groin	2		3	5
Testicle	1	2	3	6
Hip	2	4	6	12
Thigh	1	2	7	10
Leg	1	5	7	13
Foot		2	1	3
Lumbar	4	5		9
Sacral		1	2	3
Buttocks	1	3		4
Pubic		3	3	6
Renal colic			1	1

The regional pains above tabulated most frequently occurred in groups. Of these, the genito-urinary was the most common, and characterized by pain in the bladder, urethra, and penis, especially during urination. The rectum and perineum were also often grouped together, and the pain there was generally due to pressure from the enlargement of the gland, which was often sufficient to greatly reduce the lumen of the rectum and render defecation difficult. The other groups of symptoms may be classed as referred rather than local. Among them we notice three distinct groups. Those radiating to the groin and testicle, probably through the genital nerves; those radiating to the lower extremities, probably through the sciatic nerves; and those radiating to various portions of the body through the lumbar nerves. The explanation of these pains is probably the same as that given in the chapter on chronic prostatitis, simply a reference of painful stimuli to other nerves running into the same segment of the cord. As the seminal vesicles were involved in the great majority of the cases, it is impossible to say that the presence of these neuralgias does not always indicate a periprostatic invasion of the disease, as held by Motz. There were, however, two cases in which no involvement of the seminal vesicles was made out in which referred neuralgias were present.

Hematuria was not an important symptom, being present in ten cases —six slight and four considerable. Some of these were associated with vesical calculus and intravesical growth of the carcinoma. Hematuria seems to be more suggestive of vesical tumor or calculus than of simple

cancer of the prostate, and is certainly not so commonly present as in cases of benign hypertrophy of the prostate. (In an analytic study of one hundred and forty-five cases I found hematuria present in 15 per cent.) The absence of hematuria is due to the fact that carcinoma of the prostate does not invade the bladder except in a small proportion of cases. Its invasion is perivesicular and pelvic rather than intravesical.

Examination.—Both lobes were found to be enlarged in all but one case. In fifty cases the enlargement was about equal, but in twenty-six cases one lobe was larger than the other. The enlargement was characterized as considerable in forty-one; moderate in thirty, and slight in seven. As a rule, the impression conveyed was that of a greater enlargement than was actually present. This was due to the fact that the seminal vesicles, the intervesicular space, and sometimes the membranous urethra were also involved and formed one mass with the prostate. The surface was smooth in twenty-six cases; irregular in thirty-six, and nodular in thirty-three. In many cases the outlines were as regular and definite as in prostatic hypertrophy and there were no nodules or irregularities present. Tenderness was also not a marked symptom, being present in moderate degree in only eight of the cases.

The practically universal finding was marked induration, the prostate being described as very hard in seventy-three cases. In some of the other cases the notes were not very carefully made. This induration was generally of stony hardness, almost incompressible, and involving all of the prostate. In eight cases a few soft areas were felt in the generally indurated mass, but in only one case was an entire lobe soft, elastic, and apparently uninvolved in the carcinoma. In this case the carcinoma involved one lobe of the prostate, the seminal vesicle, and adjacent pelvic structures, and the patient suffered from severe sciatic pains on that side. The membranous urethra was probably involved in a large proportion of cases, but careful examinations in this regard were only made recently, since which time twelve cases showing more or less extensive involvement have been discovered. Not infrequently the disease involved the triangular ligament and sometimes the bulbous urethra.

Notes as to the condition of the seminal vesicles were not always very carefully made, and in ten cases no note as to their condition was recorded. In five cases they could not be palpated and in six cases they were definitely stated to be uninvolved. In eight cases only one vesicle was found involved, but in fifty-two cases both were involved. The space between the seminal vesicles has also only recently received proper attention, and no notes were made on forty-one cases. Among the remaining cases it was definitely stated to be uninvolved in nine and involved in thirty-eight. The detection of enlarged glands in the pelvis is often a very difficult matter. They are usually found very high up along the lateral wall of the pelvis or in the sacral fossa, and are often completely masked by the considerable enlargement above the seminal vesicles. Enlarged glands were definitely palpated in fifteen cases in the pelvis, four times in the iliac region, twice in the groin, and once in the mesentery of the colon.

Clinical Findings.—*Prostate.*—In my series of eighty-seven cases marked induration of the prostate was an almost invariable finding. In the great majority of cases it was general, both lateral lobes and the posterior commissure being of stony hardness. In a small proportion of cases the induration was less or a small area which was somewhat soft was found. The induration was of much more marked degree than is almost ever seen in simple hypertrophy, being of a peculiar unyielding density which is almost pathognomonic. In cases of hypertrophy with considerable inflammatory fibrosis or with small concretions or calculi an induration suggestive of carcinoma is sometimes encountered, but firm pressure almost always elicits some elasticity, probably owing to adjacent non-indurated portions of the gland, which is not seen in carcinoma.

The popular idea that prostatic carcinoma always presents an irregular, nodular, rough posterior surface is entirely erroneous. I have seen many cases in which it was perfectly smooth and the shape of the prostate as symmetrically rounded as in hypertrophy. This is particularly true of the early cases, in which the posterior capsule is entirely intact and the rectum free from disease. Often, however, the surface is irregularly lobulated, sometimes nodular or even very rough, with irregular prolongations anteriorly around the membranous urethra or even into the perineum or perirectal fossæ. Only rarely is the rectum involved until late in the disease. The mucous membrane is generally intact, and often only a few shot-like bodies are felt in the rectal wall, which may be more or less adherent to the prostate. The rectal cavity may be seriously diminished in size owing to the enlargement of the prostate.

Seminal Vesicles.—These are most frequently involved, for, as shown above, the absence of capsule at the base of the prostate and the fact that vessels, nerves, lymphatics, and seminal ducts lead in this direction, make this region the most easy of access in the spread of the disease. In early cases a small area of induration at the base of one or both seminal vesicles or in the vasa deferentia and continuous with the prostate is felt. It here presents a peculiar flat plateau which is easily distinguishable from the prostate by a definite notch on each side and a shallow transverse depression showing where the vesicles join the prostate. This plateau should always be very suggestive of carcinoma. In later cases one or both seminal vesicles may be extensively involved, the vasa deferentia may be palpable as enlarged, indurated cords, and all of these structures may be bound together and to the pelvic wall, forming in some cases an irregular mass which skirts along the lateral wall of the pelvis beyond the reach of the finger. In a few cases definitely enlarged lymph-glands can be palpated along the pelvic wall or in the sacral fossa. Most often they cannot be found, and their occasional presence in cases of simple prostatitis renders their finding of little diagnostic value.

Cystoscopy.—Instrumentation of the urethra and bladder should be avoided where the diagnosis is already evident and the urinary symptoms not severe enough to warrant intervention. In other cases catheterization and possibly cystoscopy may be indicated. A small, straight, rubber

Nélaton catheter is usually the easiest instrument to pass. As stated above, the lateral lobes of the prostate generally show no intravesical enlargement. The median portion in the early cases also shows no enlargement, but in the later cases a rounded bar or lobe is often present. The bladder is involved late in the disease, and then generally as an elevation of the trigone, occasionally with ulceration and rarely an intravesical polyp.

Before withdrawing the cystoscope it is important to insert a finger into the rectum to examine the tissues between it and the cystoscope. In cases of cancer a marked thickening of the suburethral portion is present and the beak can usually not be felt owing to a subtrigonal mass of infiltration. These, taken in connection with the absence of intravesical lobes and a stricture of the entire prostatic urethra, usually justify the diagnosis of cancer when the prostate is of stony hardness.

Diagnosis.—For other remarks than those just made see section on prostatic hypertrophy, p. 425.

Palliative Procedures.—When the diagnosis has not been made early enough to warrant the radical operation with the hope of permanent cure, the question of palliative treatment arises. In many cases the urinary symptoms are not sufficiently severe to necessitate any treatment of the prostate. In other cases, although urination may be somewhat difficult and painful, and a certain amount of residual urine may be present, the patient can get along quite well without any special treatment. In other cases these symptoms may be so severe as to require relief, and in such cases the use of the catheter can be adopted with success. Owing to the usual absence of marked median enlargement the coudé catheter is not necessary; in fact, it is often more difficult to pass than a straight rubber catheter, which is generally the best instrument for the purpose. The largest catheter which can be passed with comfort should be employed in order to keep the urethra somewhat dilated. As a rule, owing to the strictured condition of the urethra it is necessary to use small instruments, and in a few instances a stiff catheter, gum or silver, may be necessary. The catheter should be used frequently enough to give the patient rest at night and comfort during the day. When catheterization becomes extremely difficult or painful, other measures of relief will have to be considered. The simplest of these is suprapubic drainage, but partial perineal or suprapubic prostatectomy or the Bottini operation may be performed. Of these, suprapubic drainage is, as a whole, the simplest, and in its performance the operator should endeavor to provide the most comfortable sinus that is possible. The suprapubic wound should be small, so as to hasten its healing. The bladder should be opened well up on the anterior wall at least two inches distant from the prostatic orifice, so that the end of the drainage-tube will not impinge upon the prostate and trigone of the bladder. After the operation it is well to close the bladder tightly around a rubber drainage-tube, which should be about 1.5 cm. in size and long enough to reach a bottle beneath the bed. A small gauze wick should be placed in the prevesical space and the suprapubic wound partially closed with interrupted sutures of

silver. With a very small suprapubic wound there is no objection to getting the patient out of bed into a wheel-chair in a few days after the operation. Within two weeks it is generally possible to remove the tubes and insert a permanent apparatus, such as that shown in Fig. 240. This apparatus consists of a silver plate which is fastened to the body by means of straps around the waist and the perineum, with a curved tube through which a large rectal tube can be inserted into the bladder and held in place by means of a thumb-screw, thus making it possible to adjust the tube to the length of the sinus so that it will not impinge against the base of the bladder, and thus cause pain. In a short time the tube will generally be so tightly grasped by the walls of the sinus that very little leakage occurs. During the night the tubes may be coupled to a longer tube which leads to a bottle in a chair by the side of the bed. This receptacle should not be at a lower level than the bladder, else the bladder will become contracted as a result of its remaining continuously empty from siphonage. During the day the stopper is removed when the desire to urinate comes. The patient often remains fairly comfortable with a bladder of normal size and contractility. Another form of drainage apparatus, described by Bloodgood, has been extensively employed with excellent results. In this apparatus a short rubber tube is fitted into the suprapubic fistula and drains into a rubber bag which surrounds its external orifice and lies against the abdomen, to which it is attached by a circular band.

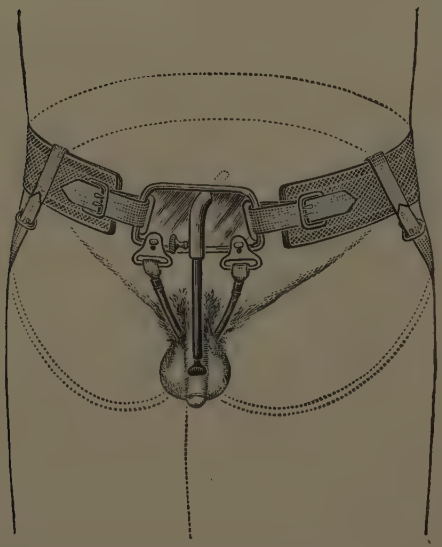

FIG. 240—SUPRAPUBIC APPARATUS.

The Bottini operation has been employed by the writer in seven cases of cancer of the prostate, and Furstenheim has published five cases from the practice of Freudenberg and two from the literature. A study of these fourteen cases shows that the Bottini operation is generally surprisingly efficacious. Voluntary urination is established at once and soon becomes fairly normal. In Furstenheim's cases the good result was maintained for nearly a year before marked obstruction to urination came on again. In one of my cases the patient was free from pain and discomfort at the end of four years, although the seminal vesicles were markedly involved and general glandular metastases were present. The operation does not seem to lead to carcinomatous ulceration of the urethra and bladder, and Furstenheim says that after expulsion of the sloughs the wounds are soon covered with smooth mucous membrane.

The technic of the operation is similar to that employed in benign

hypertrophy. Care should be taken to see that the beak of the instrument does not slip into the urethra; a medium-sized blade should generally be employed; the incisions should be made with the guidance of a finger in the rectum and generally not more than 3 cm. in length. General anesthesia is not necessary and the patient is usually able to void urine at once. The after-treatment consists in the use of diuretics, urotropin, outdoor life, etc.

The objections to the Bottini operation are the fact that it is done somewhat in the dark, that it is sometimes very hard to introduce the instrument through the carcinomatous stricture of the urethra, and that the mortality is not inconsiderable. The immediate results are often brilliant, but the obstruction is apt to recur much sooner than after a palliative partial perineal prostatectomy.

Suprapubic prostatectomy or partial excision of the prostate has been employed nine times by seven operators. A study of the results obtained in these cases shows generally very little relief afforded, a rapid increase in the extent of the disease, and before long considerable pain and a wretched existence. In most cases obstruction to urination has returned and other means of relief had to be afforded. In a few notable instances, however, the palliative results have been very satisfactory. In one of my cases, in which the prostate with a portion of its capsule and urethra was completely enucleated in one piece, the patient was entirely relieved of urinary obstruction and lived in perfect comfort, as far as his pelvic organs were concerned, for three and a half years, dying of retroperitoneal metastases in the region of the left kidney.

Perineal Prostatectomy.—In 1907, after a careful study of the literature, Motz was able to collect eight cases of cancer of the prostate which had been treated by partial perineal prostatectomy. In nearly all of these cases the diagnosis was made after the operation. Among these there were only four in which the result was at all satisfactory. In two cases of Rafin there was slight improvement, but one patient died at the end of two months and the other at the end of twelve months. Pousson reported one case in which the patient was apparently cured, but he was followed for only nine months after the operation. The most satisfactory case was that of Harrison, in which the patient was entirely comfortable sixteen months after the operation. The others were little improved and died in four or five months.

The writer has performed the operation of conservative perineal prostatectomy upon ten cases, in the first six of which the diagnosis was not made until after operation. In four cases, operated upon during the past two years, the disease was recognized as incurable carcinoma before operation and a conservative prostatectomy was carried out simply to relieve the obstruction to urination. The results obtained have been surprisingly good. With one exception the wound has healed as promptly and satisfactorily as in benign cases, and practically normal urination has been established. With the exception of one case all of the patients have lived over one year, three have lived for two years, and one is still alive four years after the operation. In only two cases has there been

a recurrence of the obstruction to urination, and in three cases the results are excellent two years after the operation. The operation performed in almost all of these cases has been similar to that for benign hypertrophy, the three lobes being removed and the urethra carefully preserved. These surprisingly good results have led me to employ this method as a palliative operation in cases too far gone for a radical operation, and if the relief afforded is maintained, conservative perineal prostatectomy would seem to be preferable to either the Bottini operation, suprapubic drainage, or even the catheter life, where this is possible with comfort.

Radical Operations.—I have been able to find but five cases in the literature in which a radical operation has been performed for primary carcinoma of the prostate. In three cases the prostate was completely excised, but the seminal vesicles and the adjacent portion of the vesical trigone were not removed. Death resulted in all three cases, once from operative shock and twice from recurrence. One of these cases is interesting because the operation was performed as far back as 1882 by Leisrink. The second case was operated on in a similar manner by Czerny in 1889, with operative recovery. In 1898 Fuller performed the operation through a suprapubic wound, excising the prostate and a small portion of the anterior wall of the bladder. He found it impossible to suture the bladder to the membranous urethra, but after a tedious convalescence the suprapubic wound finally healed and urine passed through the urethra. The patient died eleven months later from recurrence. In 1891 Küster performed a most extensive operation in which he freed the entire bladder through a suprapubic incision and then, through a perineal incision, divided the membranous urethra and the ureters at their vesical juncture and removed the bladder, the seminal vesicles, and the prostate in one piece. The ureters were then transplanted into the rectum and the patient lived five days after the operation. In the following year Harris did almost as extensive an operation, removing the prostate and all but the apex of the bladder through a suprapubic incision. The ureters were transplanted into the small vesical cap remaining of the vertex of the bladder, and the immense space left after the removal of the prostate and bladder was allowed to heal by granulation. The patient recovered from the operation and lived for two months. Autopsy showed that the space from which the prostate and bladder had been removed was almost completely lined by epithelium which connected the urethra with the remaining portion of the bladder. The right kidney was normal, both ureters were patent. Numerous carcinomatous metastases were found.

In five cases of carcinoma involving the rectum and the prostate several operators have attempted excision of both rectum and prostate, four cases died soon after the operation, but one by Demarquay, operated in 1873, remained well after two years. In this case, however, very little of the prostate was removed, as the "urethra and ejaculatory ducts were respected."

At the time when the radical operation, which will be described further on, was employed by me in 1904 I was not aware of any of the

operations for carcinoma of the prostate which had been described in the literature. A careful study of them shows that in no case was the operation described by me carried out. A study of cases and of autopsies had convinced me that, in order to obtain a radical cure of carcinoma of the prostate, it would generally be necessary to remove not only the entire prostate with its capsule and urethra, but also the seminal vesicles and the overlying portion of the vesical trigone, owing to the fact that the spread of the disease is nearly always into the tissues immediately beneath the trigone and around the base of the seminal vesicles, and I therefore decided in 1905 to carry out the following procedure:

A Radical Operation for Cure of Carcinoma of the Prostate.—The patient is placed in the exaggerated lithotomy position, and an inverted V perineal incision made, as in the operation for simple hypertrophy of the prostate, the successive steps of which are followed until the tractor has been inserted through a urethrotomy wound of the membranous urethra and the posterior surface of the prostate has been exposed, largely by blunt dissection. If there is then any doubt in the mind of the operator as to the malignant nature of the disease, an incision is made through the capsule and a section of the prostatic lobe removed for examination, frozen sections being made if necessary to establish the diagnosis, when either the simple prostatectomy operation for hypertrophy or the radical operation for cancer can be performed as the case requires. In the case of cancer the next step after exposing the posterior surface of the prostate is to free the lateral adhesions of the prostate and also the seminal vesicles as much as possible by blunt dissection; then the membranous urethra is divided in front of the tractor, as shown in Fig. 241. The handle of the tractor is then depressed markedly and the puboprostatic ligaments divided with scissors close up to the anterior surface of the prostate,

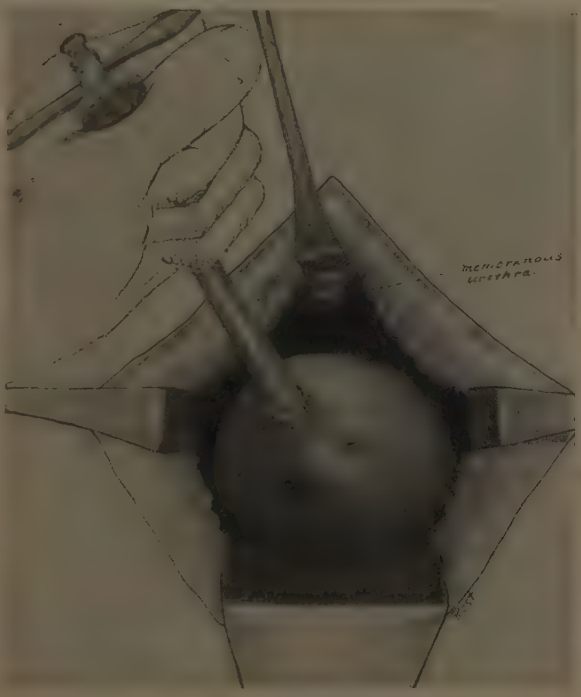

Fig. 241.—After Transverse Section of Urethra.

efforts being previously made to push away the anterior plexus of veins by blunt dissection. Fairly abundant hemorrhage usually follows, and should be controlled as much as possible by clamps and then by a gauze pack, which should be held tightly against the posterior surface of the pubes and the triangular ligament by means of a retractor.

The prostate is then drawn outward as far as possible, thus exposing the anterior surface of the bladder, which should be punctured, as shown in Fig. 242, just above the prostato-vesical juncture. This wound is now enlarged on each side by scissors, the line of division being close to the prostato-vesical juncture, until the trigone is exposed, as shown in Fig. 243. With a scalpel a curved incision is made across the trigone, thus leaving the upper angles of the trigone intact and being careful to do no injury to the ureters. By blunt dissection the seminal vesicles are then exposed, as shown in Fig. 244, and the vasa deferentia picked up with a blunt hook and divided with scissors as high up as possible. (In doing this it should be remembered that the vasa deferentia pass around the lower end of the ureters). The deeper attachments of the seminal vesicles are then freed and the mass, consisting of prostate, urethra, cuff of bladder, seminal vesicles, and about 5 cm. of vasa deferentia, removed in one piece. Hemorrhage is again encountered in the last step above described, owing to the fact that the prostatic plexus of veins, which passes up along the side of the prostate on each side, is closely attached to the lateral border of the seminal vesicle, but this can easily be controlled by ligatures or long clamps. The bleeding which comes from the vesical wound is easily controlled by the subsequent sutures, which are placed so as to anastomose the bladder with the membranous urethra, and completely close the vesical wound. This is easily accomplished, as shown in Figs. 245 and 246. As seen here, the anterior wall of the bladder is drawn down

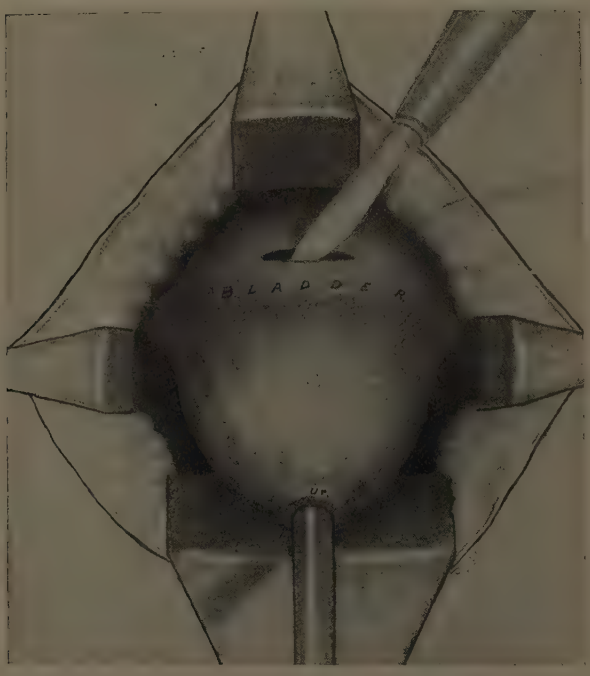

FIG. 242.—INCISION INTO BLADDER JUST ABOVE PROSTATE.

and fastened to the stump of the membranous urethra by means of interrupted catgut sutures. After forming the anastomosis with the urethra a considerable vesical wound is left posteriorly, but is easily closed by transverse sutures. I found it best to use an occasional suture of silkworm-gut in order to take care of the tension which is present. The ends of these are left long enough to emerge from the wound so that they can be removed two or three weeks later. A retained rubber catheter, which should be inserted before the vesico-urethral anastomosis is made, is fastened to the glans penis with adhesive plaster. After placing light gauze packing in the depths of the wound the levator ani muscles are approximated with two or three interrupted sutures of catgut so as to protect the rectum against post-operative necrosis, and the external wound is almost completely closed with interrupted sutures of catgut. In some instances I found it difficult to place ligatures around hemostatic clamps which were deeply placed, and have therefore not removed the clamps, but allowed them to emerge with the gauze packing from the anterior angle of the wound (they were removed twenty-four hours later). If careful attention has been given to the prevention of hemorrhage and an infusion has been begun early in the operation, there should be little or no shock.

FIG. 243.—EXPOSURE AND DIVISION OF TRIGONE.

The management of the convalescence is much the same as after simple prostatectomy, an abundance of water being indicated, the patient up in a wheel-chair in two or three days, at the end of which time the gauze packing should be removed. The retained catheter had better remain for a week. In all of my cases there has been leakage of urine through the perineum, but often not until several days after the operation, and in all cases the perineal wound has finally closed without the use of a second retained catheter or urethral dilatation with sounds. No strictures have resulted, and although incontinence of urine by day has generally been present, this can be taken care of by means of a rubber urinal.

Results.—While it is too early to draw positive conclusions and the number of cases (six) is too small, it may be stated that three cases are still alive and well, one two years and four months, one two years and three months, and one one year and ten months after the operation, and that one patient lived in comparative comfort for nine months and then died of something else. One patient died of nephritis seven weeks after the operation, and the autopsy showed that the carcinoma had been completely removed. The sixth case died of operative shock, and autopsy showed that the cancer had passed directly from the prostate into the peritoneum, which was extensively invaded. This could not be determined before operation, and as the bladder and upper portion of the seminal vesicles were free from disease the radical operation was carried out. It seems probable, in view of the absence of shock in the other five cases, that the cachexia resulting from the extensive peritoneal metastases had much to do with the patient's death immediately after the operation. In conclusion, it may be said that in symptomatology and clinical findings cancer differs markedly from hypertrophy of the prostate. The presence of pain in urethra, perineum, or rectum, and lumbago or sciatica should lead to rectal examination, and if a markedly indurated prostate is found, cancer should be suspected if the patient is over forty years of age. The discovery of a stricture of the whole prostatic urethra and the absence of globular intravesical lobes on cystoscopic examination should render the diagnosis almost positive, and if the seminal vesicles are not involved a radical operation should be undertaken. If this is done, the entire prostate, capsule, and urethra should be removed, along with the seminal vesicles and anterior portion of the trigone, in one piece. With early diagnosis many radical cures should be obtained.

FIG. 244.—FINAL SEPARATION OF SEMINAL VESICLES AND DIVISION OF VASA DEFERENTIA.

Sarcoma of the Prostate.—The first case of sarcoma of the pros-

tate to be described was that of Stafford, who in 1839 reported a melanotic tumor of the prostate in a child five years of age. In 1858 Thompson found six cases in the literature, and in 1902 Burckhardt was able to collect twenty-four cases. Proust and Vian have in 1907 collected thirty-four "incontestable" cases. I now add one case from my practice.

Age.—In these thirty-five cases in which the diagnosis has been confirmed by the microscope, fifteen, or 43 per cent., were under ten years of age, twelve, or 34 per cent., were between ten and forty-nine years of age, and eight, or 23 per cent., were between fifty and eighty years of age. In four cases the patient was less than a year old and three patients were between seventy and seventy-three years of age.

FIG. 245.—THE ANASTOMOSIS OF ANTERIOR WALL OF BLADDER TO URETHRA HAS BEEN MADE.
The rest of vesical opening is being closed.

Various types of sarcoma have been present: viz., small cell, six; large cell, three; spindle cell, five; polymorpho-cell, four; lymphosarcoma, two; angiosarcoma, two; myxosarcoma, three; adenosarcoma, one; chondrosarcoma, one; "rhabdomyoma," three; "fibroid," one. The age of the patient had little to do with the character of the tumor present, both infants and adults being found with almost every variety.

As a rule, the tumor soon reached considerable size, both in infants and in adults, and in some cases almost completely filled the pelvis. It was generally oval in form, regular with slight lobulation, but occasionally it was irregular and nodular. The consistence was variable, sometimes uniformly firm, sometimes elastic, sometimes so soft as to give the sensation of fluctuation. In many cases, however, the induration was considerable. The bladder was generally pushed upward and forward by the tumor, which grew backward beneath the base of the bladder. The mucous membrane was generally intact, but occasionally small papillomatous intravesical outgrowths were present, almost always in the region of the trigone. Enlargement of a median or a lateral lobe projecting into the bladder was rarely present. The rectum was usually

compressed, flattened, but its walls were rarely infiltrated and the mucous membrane was healthy in all cases. The urethra was almost always invaded and generally strictured. Occasionally intraurethral polyps were present. The seminal vesicles have generally been found invaded, but in a few cases they were not. The ureters were often pressed upon, thus leading to hydronephrosis. The perirectal and retroperitoneal tissues were often invaded, as were also the peritoneum, the intestines, and the pubic bones. The lymph-glands were involved in seven of the thirty-five cases, but metastases to various organs occurred more frequently.

That sarcoma of the prostate is a rare disease is shown by the fact that only one case has been detected among the immense number of cases seen at the Hôpital Necker in Paris. I have personally had one case in which the diagnosis of sarcoma of the prostate was positively made by microscopic examination, but in Halsted's service there have been two cases in which a clinical diagnosis of sarcoma has been made. My patient, a man aged fifty-one, had suffered with pain in the lower abdomen and rectum for fourteen months. Urinary trouble had been present for about six months, but had only recently become marked. On rectal examination an immense smooth mass, which almost filled the pelvis, was felt. It was very soft and homogeneous in feel and almost completely obliterated the rectum. Only 40 c.c. residual urine was present. Perineal prostatectomy was performed and the tumor found to spring from the upper portion of the prostate, the anterior two-thirds of which was apparently normal. The urethra and bladder were not invaded, but the latter was greatly elevated by the huge retrovesical mass. The tumor was composed of soft hemorrhagic material which was easily scooped out with the finger. The patient recovered and was able to void urine without difficulty and lived for almost a year. The microscope showed a sarcoma of mixed-cell type.

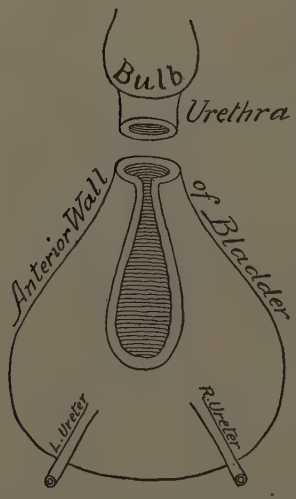

FIG. 246.—DIAGRAM SHOWING PLAN OF VESICO-URETHRAL ANASTOMOSIS.

Symptomatology.—Proust has divided his study into those of early age, twenty-four cases, and those of advanced age, ten cases. Among the twenty-four cases the first symptom was usually pain, and this did not come on until obstruction to urination developed. Constipation was frequently present, but was of secondary importance. In most cases the disease had reached great size before any symptoms were present. Among those patients older than thirty years of age the development was slower, but usually caused little trouble until later. In rare cases sudden retention of urine occurred, but often there was very little obstruction to either urine or feces. At times, owing to its softness it is difficult to differ-

entiate from abscess. In the adult sarcoma of the prostate is generally less regular than hypertrophy, produces less lengthening of the canal, and is more infiltrated. The tumor is often retrourethral and retrovesical and produces more pressure upon the rectum than simple hypertrophy. Sarcoma is less often accompanied by hematuria than carcinoma, which is usually much harder and characterized by indurated prolongations into the region of the seminal vesicles. In my case the consistence was much softer than is ever seen in simple hypertrophy, and the immense, smooth, globular mass could never have been mistaken for carcinoma.

Treatment.—In young patients operations have been absolutely unsuccessful, and suprapubic cystotomy is apparently the only procedure of value. The results of operations for sarcoma in the adult have not been brilliant, but several cases in which the patient was relieved for a considerable period are on record. Spanton in 1882 enucleated through the perineum a very large sarcoma of the prostate, but the patient died on the following day. In 1894 Socin removed a tumor the size of two fists through the anus and rectum, without injury of the urethra or bladder. The rectum was then sutured. The patient showed no evidence of recurrence for three years. Verhoogen in 1898 extirpated the prostate with its capsule and urethra after division of the membranous urethra. A persistent perineal fistula resulted and the patient died nine months later of a recurrence of the sarcoma. McGowan reported a case in which the patient was apparently cured, but died four years later of cancer of the liver. A patient of Fuller's lived eleven months.

In my case, which was attacked through the perineum, it was impossible to perform radical excision, and I could only scoop the broken-down material within the capsule. The obstruction to urination was removed, but the patient died one year later.

Owing to the fact that sarcoma of the prostate generally begins in the upper portion of the posterior part of the gland and rapidly involves the capsule and retrovesical structures, it seems probable that radical measures can never be as successful as in cancer. In some of the more benign types sarcoma may remain encapsulated for a time, as in Socin's case, and a complete extirpation through the perineum may be possible. In such cases the urethra may not have to be opened. The suprapubic route will probably not be available, owing to the retrovesical character of the growth. Suprapubic drainage may be necessary in some cases.

It gives me pleasure to acknowledge the considerable assistance in the preparation of this chapter which I have received from Drs. John T. Geraghty, Charles M. Remsen, John R. Caulk, and E. A. Fletcher.

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CHAPTER LX.

SURGERY OF THE PENIS AND URETHRA.

By Orville Horwitz, M.D.,

PHILADELPHIA.

ANATOMY.

Normally, the **penis** is a pendulous organ, varying in size and shape. It is made up of three parts—root, body, and head. It is covered by an investing sheath of skin and fascia. The integument covering the body of the penis is of a dark color, thin, and distensible.

In the normal condition the skin covering the penis forms an investing tubular sheath—the **prepuce,** or foreskin. At the *preputial orifice* the skin is reflected backward or turned under, and is now converted into mucous membrane. The mucous lining passes backward to the coronal sulcus, into which it is inserted, covering the entire glans penis with a firmly adherent mucous membrane. In the median line, on the under surface of the glans, is a fold of mucous membrane known as the *frenum præputii.*

The *corpora cavernosa* form more than one-third of the entire bulk of the organ, and, in conjunction with the corpus spongiosum, give to the penis the shape of a cylindric, three-sided column. The *corpus spongiosum* is lodged in the groove on the under surface of the corpora cavernosa, and runs parallel with these bodies.

The glans penis covers the anterior rounded extremity of the corpora cavernosa, and expands into a cone-shaped body, at the base of which is the *corona glandis;* behind this is a deep sulcus, known as the *cervix* or *neck.* Below the center of the apex is a vertical, slit-like opening—the *meatus urinarius.*

The organ receives its *blood supply* from the dorsal artery of the penis; the artery of the corpus cavernosum; and the artery of the bulb. There are both a superficial and a deep dorsal vein; the latter is lodged beneath the fascia.

The *nerve supply* is derived from the internal pudic and hypogastric plexus.

The **urethra** is divided anatomically into three parts—penile, membranous, and prostatic; for clinical purposes it is divided into two —anterior and posterior. The *anterior portion* extends from the meatus to the anterior leaflet of the triangular ligament; the *posterior* is that portion beyond the ligament, and includes the membranous and prostatic urethra. The length of the urethra varies, being generally from eight to nine inches long.

The differentiation of the inferior from the superior wall of the urethra

is an anatomic point of great surgical value, and is to be borne in mind when catheterism or operation for the relief of a stricture is attempted. The superior wall is smoother, less vascular, and not so intimately connected with important structures as the anterior.

The **penile urethra** is lined by a delicate mucous membrane on which are the openings of numerous ducts leading to the urethral glands; these are known as the *glands of Littré*. The penile urethra has an expansion at each end. The dilatation back of the meatus is called the *fossa navicularis;* on the roof of this there is a reduplication of the mucous membrane called the *lacuna magna*.

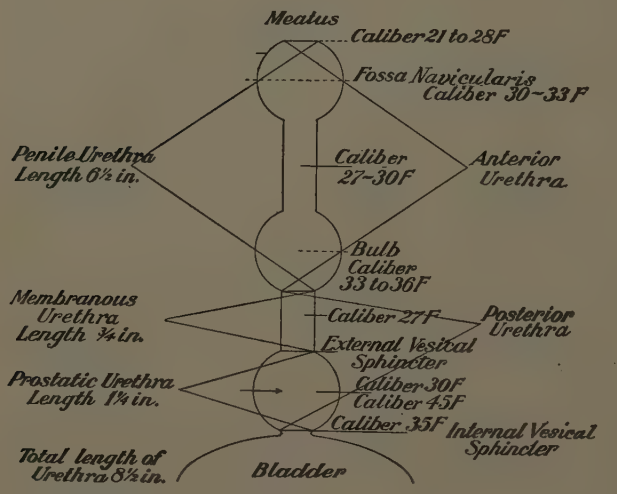

FIG. 247.—SHOWING DILATATIONS, CONTRACTIONS, CALIBER, AND LENGTH OF URETHRA.

The **membranous urethra** lies between the anterior and posterior layers of the triangular ligament.

The **prostatic urethra** passes downward and forward, and, on reaching the posterior layer of the triangular ligament, becomes the membranous urethra.

DISEASES OF THE PENIS.

Inflammations of the penis may be acute, subacute, or chronic. *Acute inflammations*, the most common variety, usually involve only the skin and subcutaneous connective tissue.

A low grade of inflammation occasionally attacks the corpora cavernosa. Traumatism, syphilis, gout, rheumatism, urethritis, and stricture are regarded as probable causes of this condition.

A *chronic inflammation* involves only the skin and the cellular tissue, and is generally limited to that portion of the prepuce near the frenum.

The condition may be due to injury, venereal infection, rheumatism, gout, typhoid, various skin diseases, tuberculosis, or ulceration associated with malignancy. Chronic inflammation of the skin and connective tissue is rare.

Symptoms.—These are swelling, pain, and discoloration. Difficulty in micturition and frequent and painful erections may occur. When suppuration is threatened, the symptoms become intensified.

The lymphatic vessels on the dorsum of the penis are frequently inflamed, indurated, and tortuous, and the inguinal glands also become involved. Phimosis or paraphimosis may develop.

Treatment.—Cleanliness is best secured by immersing the organ frequently in six ounces of hot water to which a teaspoonful of table-salt is added, followed by the application of a cooling, sedative lotion, such as lead-water and laudanum. The patient should be kept at rest, with the organ elevated. Heat or cold may be of service. Cold is indicated in the incipient stage, but its effect should be carefully observed. Hot applications are indicated in nervous patients, and may be employed with advantage in the second stage, when the condition is one of stasis. Phimosis or paraphimosis may require surgical intervention.

An inflammation due to suppuration or to extravasation of urine demands early evacuation of the pus or fluid by multiple free incisions.

In ordinary acute inflammation rest, restricted diet, and the avoidance of constipation should be enjoined. Sexual excitement should be controlled by bromids, camphor, or opiates.

Gangrene of the penis may be due to local or constitutional causes. Among the former are various inflammations, phlegmonous erysipelas, extravasation of urine, injuries of the penis, phimosis, paraphimosis, foreign bodies in the urethra, or strangulation due to a mechanic constriction. Among constitutional causes are the exanthemata, especially scarlatina and smallpox, and various febrile states.

The gangrenous process may be either moist or dry, circumscribed or diffused.

Symptoms.—*Localized moist gangrene* is usually preceded by inflammatory symptoms; later the organ becomes enormously swollen and discolored, the skin assuming a bluish-black or purple hue, with greenish-black spots here and there. Vesicles form which burst. A line of demarcation generally forms, the necrotic area being cast off as a slough. A penetrating, offensive odor is present. The pulse is usually accelerated, and there is a slight rise of temperature.

In the *dry form of gangrene* the organ becomes edematous, the gangrenous process first manifesting itself by the appearance of purple spots. A vesicle forms that ruptures, discharging a bloody serum and leaving a dark, dry surface exposed. In dry gangrene due to thrombosis of the iliac vein the pain is intense; when due to other causes there is little discomfort. Sometimes a disagreeable burning sensation is complained of, the affected part becoming black, cold, dry, and wrinkled.

Treatment.—Every effort should be made to remove the cause. Phimosis demands circumcision, and paraphimosis should be relieved. When due to extravasation of urine, external perineal urethrotomy should be performed. Foreign bodies in the urethra should be removed.

In *moist gangrene* the patient should be kept at rest, with the penis elevated. Frequent immersion of the organ in hot water is beneficial. Incision through the skin may be necessary for the purpose of trimming off the sloughing tissue. The raw surface may be swabbed with phenol, bathed with hydrogen dioxid, irrigated with hot bichlorid solution,

1:5000, and a moist antiseptic dressing applied. If the anterior urethra is involved, perineal drainage should be established.

Dry gangrene involving only the prepuce demands circumcision. When the body of the organ is affected, the formation of the line of demarcation should be awaited before amputating. Opium should be administered to relieve pain and quiet sexual excitement.

Hypertrophy of the Penis.—Hypertrophy of the entire organ is extremely rare, and occurs generally as a sequel to a chronic inflammation of the lymphatic vessels of the penis or of the inguinal glands. It may be localized or general.

In the *localized form* the structures usually affected are the prepuce and the neighboring integument, which become thickened and dense. There is no pain or discomfort.

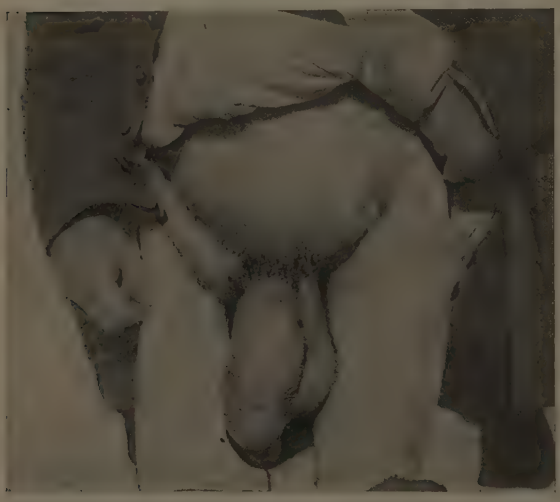

FIG. 248.—HYPERTROPHY OF THE PENIS FROM INJURY TO THE LYMPHATIC VESSELS. DOUBLE BUBO.

A *general hypertrophy* may follow the localized variety, and inflammation of the lymphatics of the penis, accompanied by suppuration of the inguinal glands, may ensue.

Treatment.—In the *localized* variety frequent immersions in hot water and small doses of mercury bichlorid given in conjunction with sodium iodid are useful. Stricture requires dilatation or division. In the *general* form treatment is useless.

CONTUSIONS, WOUNDS, AND INJURIES OF THE PENIS.

These may vary from a trivial abrasion to complete destruction or even ablation of the entire organ.

Contusions.—These are usually caused by direct injury or by pressure.

The **symptoms,** when the injury has been slight, consist of numbness, pain, and swelling; when severe, swelling and discoloration appear early and are diffuse. The prepuce generally becomes enormously distended, giving rise to phimosis and painful erections.

Treatment.—In slight contusions no treatment is required. In severe cases, or in debilitated or elderly patients, hot applications are preferable to cold. When there is evidence that extravasation of blood

is taking place and cannot be controlled by ordinary means, the contused area must be incised, clots removed, bleeding vessels ligated, and the wound packed with iodoform gauze. Edema of the prepuce may be so great as to require multiple punctures through the integument.

Wounds of the Penis.—As a rule, all wounds of the penis except contusions are accompanied by severe hemorrhage and recurring erections. When the wound involves the fibrous sheath of the organ, the erectile tissue, the urethra, or important blood-vessels, permanent interference with erection may ensue.

Wounds of the penis, even when severe, do not threaten life. In many cases, however, as the result of the sexual disability, the character and disposition of the individual undergo a complete change, the subject becoming morose and sullen; some develop melancholia with suicidal tendencies.

Incised Wounds.—These are generally inflicted for criminal purposes or by the insane.

Lacerated and Contused Wounds.—These are generally serious, and may be followed by deformity and interference with erection.

The primary hemorrhage is usually slight. Edema and discoloration are generally present. There are frequent erections, and if infection occurs, pain becomes more intense, and sloughing of the tissues may follow.

Punctured wounds are rarely seen, and are usually inflicted by some sharp instrument or by animals.

Stab wounds have occasionally been observed.

Gunshot Wounds.—A gunshot wound involving the penis is usually associated with injury to other organs. The ball may penetrate and lodge in the organ, or perforation may take place. A shot wound that involves the urethra is a grave injury, as extravasation of urine, with its disastrous consequences, is sure to take place. As a rule, there is considerable edema, causing either a phimosis or a paraphimosis. Primary hemorrhage is usually slight, but considerable extravasation of blood into the connective tissue occurs, and secondary hemorrhage is the rule. If the wound becomes infected, there is sloughing. Severe shock is not infrequent.

Treatment.—The indications are to arrest hemorrhage, render the wound aseptic, remove foreign bodies, approximate the edges, control erections, and overcome interference with urination. A catheter should be inserted in every case, even if the urethra has not been injured, as not infrequently the subsequent swelling gives rise to retention of urine. When the urethra is lacerated or ruptured, an external perineal urethrotomy should be performed. In gunshot wounds, if the bullet is embedded subcutaneously, it should be extracted. If it has passed through the organ, the track of the bullet should be irrigated with a weak bichlorid solution and hydrogen dioxid injected; this should then be washed away with normal salt solution. Should the disorganized tissue slough, the wound should be laid open and allowed to granulate. Amputation is contraindicated, even in apparently hopeless cases, for the vascularity

of the organ is so great, and the firm fibrous sheath serves as so excellent a medium for approximation, that most gratifying and unexpected results will frequently be obtained as the result of conservative surgery.

Injuries of the Penis.—A **tear or rupture of the frenum** is usually inflicted during sexual intercourse, and is generally accompanied by a sensation as of something giving way; there is sharp pain; erection suddenly subsides, and free hemorrhage usually follows.

Treatment consists in applying a catgut ligature to the bleeding vessel as soon as possible. When the artery cannot be isolated, the bleeding point should be seized with hemostatic forceps and a ligature applied that will include the tissue surrounding the vessel.

Laceration of the Sheath of the Corpora Cavernosa (Fracture).—This injury is usually confined to the cavernous bodies, and is generally unilateral; the sheath of the corpus spongiosum may, however, also be implicated. The accident can occur only when the organ is erect.

Symptoms.—When damage to the erectile tissue has been slight, as in attempts to straighten the curve of chordee, there will be pain, instant subsidence of the erection, with gradual development of edema and discoloration, the penis inclining slightly toward the injured side. Such cases usually recover without developing complications. In extensive rupture there is a sensation as of something suddenly giving way, and the penis is deflected toward the injured side. If the laceration involves the sheath on both sides of the cavernous bodies, the portion of the organ beyond the seat of rupture is preternaturally movable. An intense sickening pain and syncope may supervene. The organ becomes enormously swollen and discolored. Blood is rapidly diffused over adjacent structures, and hematoma may form. Rupture of the urethra is a serious complication; death may follow as the result of pyemia, associated with gangrene, due to extravasation of urine.

Prognosis regarding life is favorable, but the sexual function is frequently permanently impaired.

Treatment in mild cases includes elevation of the penis, the application of a cold evaporating lotion, and the administration of purgatives and anaphrodisiacs. In severe cases prompt operative interference is demanded. A free incision should be made down to the seat of the injury, clots removed, bleeding vessels ligated, and the wound rendered aseptic; the deep structures should be approximated by buried catgut sutures, and the cutaneous surfaces brought together by interrupted silkworm-gut sutures. A moist antiseptic dressing should be applied. If the urethra is involved, the same measures should be employed as in extravasation of urine due to rupture of the urethra.

Dislocation of the penis is a rare injury, usually produced by traumatism inflicted upon the anterior portion of the organ while flaccid. The penis may be forced into the scrotum, perineum, groin, or abdomen. Occasionally the dislocation has given rise to rupture of the urethra with extravasation of urine. The subject is often unaware that a serious accident has happened until hemorrhage, difficulty in micturition, or retention of urine occur. The organ presents a shrunken appearance,

the cutaneous sheath containing a mass of clotted blood. Difficulty in urination is usually an early symptom.

Treatment.—If the case is seen early, an attempt should be made to make the penis retrace the route it took when luxation occurred. When extravasation of urine has taken place, external perineal urethrotomy should be performed at once.

Strangulation of the penis occurs as the result of a constriction of a portion of the shaft of the penis by an encircling bit of string or tape, an elastic band, or a ring. If the circulation is entirely cut off, gangrene will follow.

The *symptoms* appear immediately after strangulation is complete. Ulceration occurs, and the constricting band becomes deeply embedded. When the circulation is completely occluded, the penis immediately becomes enormously swollen, tense, and cold, the skin assuming a shiny appearance. Difficult urination is present from the onset, and retention soon follows. If relief is not prompt, rupture of the urethra or gangrene may develop.

Treatment consists in removing the constricting object as soon as possible. If extravasation of urine has occurred, perineal drainage must be instituted.

Aneurism of the cavernous bodies or dorsal artery of the penis is extremely rare. A case is recorded by Malgaigne in which the condition developed as the result of a punctured wound.

A rupture of the superficial veins of the penis occasionally occurs as the result of a fall or a blow. There are slight swelling and discoloration, and hematoma may develop, demanding operative measures.

MORBID CONDITIONS OF THE PREPUCE AND PENIS.

Phimosis.—This condition may be either congenital or acquired. The prepuce completely covers the glans penis, the orifice being so contracted that retraction is either impossible or accomplished only with difficulty and pain. If restoration is not prompt, paraphimosis may develop.

Symptoms.—In *congenital phimosis* there is difficult urination, the bladder being emptied only after considerable straining. If the obstruction is not relieved, congestion of the urethra and bladder follows, and urethritis and cystitis develop. There are pain and an urgent desire to urinate. The urine is cloudy, due to the presence of pus, and in poorly nourished children it contains an excess of either urates or phosphates. Retention may occur, but incontinence is more common. The symptoms closely simulate those of vesical calculi. In long-standing cases of urinary obstruction the condition is frequently complicated by the formation of vesical calculi. It should, therefore, be a routine method of treatment, in phimotic cases, to explore the bladder immediately after circumcision has been performed. In these cases, in addition to the symptoms of irritable bladder, the child manifests a tendency to pull at the prepuce; tenesmus, priapism, and prolapse of the anus are also present.

A *pin-point-sized opening of the prepuce* is attended with dribbling of urine, the retained urine in the preputial sac ultimately giving rise to balanitis.

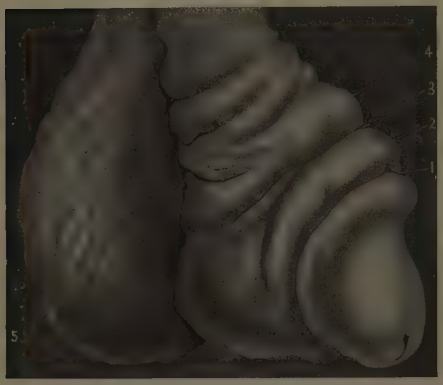

FIG. 249.—PARAPHIMOSIS (Fowler).
1, The coronary sulcus; 2, edematous and brawny collar of mucous membrane; 3, deep furrow the actual seat of constriction; 4, ridge of swollen skin; 5, scrotum.

A *tight and adherent prepuce* retards the development of the glans, and may give rise later to the development of balanitis, with adhesion of the prepuce to the glans penis, thickening and hypertrophy of the foreskin, leading, in children, to sexual excitement and a tendency to masturbate. In later life it is known to be a strong predisposing factor to the development of epithelioma, and is a serious complication in venereal infection.

The *acquired form of phimosis* is quite common, and is due to inflammatory changes brought about by balanoposthitis, elephantiasis, hypertrophy from chronic lymphangitis, venereal infections, and other chronic inflammatory processes. The condition often disappears after the inflammatory process has subsided. A permanent phimosis of the acquired variety exhibits but little redundancy, but shows a marked contraction of the preputial ring, which is fibrous in character.

The **treatment** for phimosis is operative (see p. 487).

Paraphimosis.—This is a more serious condition than phimosis. It may be described as a strangulation occurring behind the corona glandis, caused by retraction of a prepuce having a constricted orifice. The condition may be acute, subacute, or chronic. When it occurs independently of inflammatory disease of the organ, it is said to be "accidental."

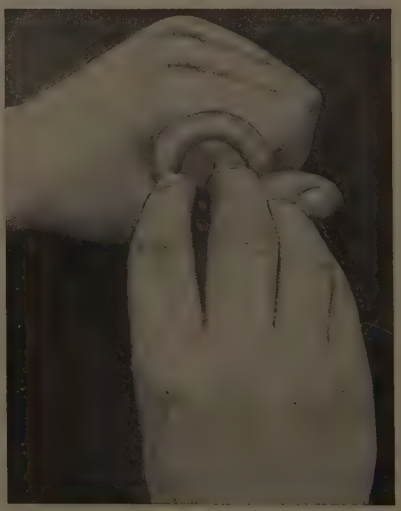

FIG. 250.—REDUCTION OF PARAPHIMOSIS. FIRST METHOD (Fowler).

The **symptoms** of the *acute and subacute varieties* differ only in degrees of severity. The earliest symptom is swelling of the folds of the prepuce behind the glans penis. These bands may reach an enormous size. They take on an angry red color, and, if the constriction remains unre-

lieved, may become black. The skin of the entire organ becomes edematous, and the penis assumes a bizarre appearance. Pain is intense. A tight constriction that is allowed to go unrelieved may cause gangrene; more commonly, ulceration of the constricting bands takes place, relieving the obstruction to circulation and resulting in cure.

A *chronic paraphimosis* usually follows an acute condition in which the symptoms were mild. According to Jacobson, it may develop spontaneously, without producing any discomfort. The penis remains hypertrophied and misshapen.

Treatment consists in prompt reduction by manipulation; if this fails, division of the constricting band is indicated (see p. 488).

Priapism.—In this condition the penis is continually in a state of either semi- or complete erection, sexual excitement and desire being absent. In the *incomplete form* there is marked turgescence, the body of the organ being partially distended and the glans remaining soft and flaccid. There is but slight discomfort. In the *complete variety* the organ is erect, firm, and painful.

Fig. 251.—Reduction of Paraphimosis. Second Method (Fowler).

The condition may develop suddenly, without assignable cause; more commonly it is due to an inflammatory process affecting the body of the penis or the urethra. It may be symptomatic of injury or disease of a distant structure of the body, and may follow various operative procedures. In children it results from an adherent prepuce, vesical calculi, or ascarides.

The severity of the **symptoms** is dependent upon the exciting cause and the form of the erection. The most distressing symptoms accompany rupture of the erectile tissues, with extravasation of blood into the cavernous envelop. Pain is proportionate to the amount of rigidity. There is difficulty in micturition, and occasionally retention occurs. Catheterism is often accomplished only with difficulty. The penis may assume the upright position, coming in contact with the pubes, or it may be bent at an angle. When the symptoms subside, the penis presents a shriveled appearance, and complete erection is impossible. Permanent impotence may follow. Phlebitis, thrombosis, gangrene, cellulitis, or abscess may complicate the condition and terminate in death.

The **treatment** in the temporary intermittent form consists in removing the source of irritation. When it results reflexly from operative procedures, rest, purgatives, and large doses of sodium bromid should be prescribed. Morphin, the bromids, chloral, and belladonna are the

only remedies that are useful. A cold moist sedative dressing should be kept constantly applied. Retention of urine calls for catheterism.

When due to extravasation of blood, *free incision* will give prompt relief and may effect a cure. In chronic cases early operation affords most gratifying results. A small incision is made into the most turgid portion of the organ, at seat of pain, or into the nodular masses, when these exist.

Fibrous Sclerosis of the Cavernous Bodies and Corpus Spongiosum.—This condition is due to the development of fibrous masses on the sheath, septum, or erectile tissue of the corpora cavernosa or corpus spongiosum. The most common form of this affection arises insidiously, *without any apparent cause.*

Any portion of the cavernous body may be involved. The masses may be unilateral, bilateral, or multiple. Usually there is a single growth, situated near the dorsum of the penis. The nodular mass de-

Fig. 252.—Horn of Penis (Demarquay).

velops slowly, and ultimately terminates in distortion and deformity of the organ, which, during erection, tends to curve toward the abdomen or to bend at right angles or in the direction of the affected side. The discomfort thus produced is the only symptom, although pain is occasionally present in the incipient stage, or in long-standing cases when turgescence occurs. In chronic cases organic impotence develops. It usually appears between the ages of forty-five and sixty, and is not so rare as is generally supposed.

The prognosis is discouraging, no form of treatment having been followed by beneficial results. The sexual disability occasionally gives rise to melancholia, and the character or disposition may undergo marked change.

Fibrous and Osseous Transformation of the Penis.—This condition is extremely rare, and little is known regarding its pathology. The bony patches may be single or multiple, and vary in size, seldom

becoming larger than a dime. When the growth develops in the erectile tissues, it may be superficial or deep.

Treatment.—This affection is incurable, and operative measures have been unsuccessful.

Horny Growths of the Penis.—These growths are rare, and of interest to the surgeon from the fact that they interfere with coition and that the base of the growth shows a tendency to undergo epitheliomatous degeneration. They occur as the result of prolonged irritation, or as sequels to papillomatous growths. Their presence gives rise to no pain.

Treatment consists of early and complete excision.

Curvature of the Penis.—This may be either congenital or acquired. A rare deformity, described as torsion, is occasionally observed. Marked curvature of the penis is usually associated with other developmental defects, such as congenital shortness of the corpus spongiosum, epispadias, or hypospadias. Where the deformity is marked, an attempt should be made to relieve it by means of a plastic operation (see p. 489).

Abnormalities of the Penis.—**Webbed penis,** or **penis palmé,** is a rare congenital deformity. The penis may be partially attached on its inferior surface to the scrotum; the body of the organ may be completely retained in the cutaneous covering surrounding the testicles, the glans alone protruding; the penis is generally stunted or poorly developed, and, finally, a hypospadias or a corpus spongiosum that is shorter than the corpora cavernosa may be responsible for the incurvation.

FIG. 253.—UNDEVELOPED PENIS; UNDEVELOPED TESTICLE.
Female attribute showing by breast, pelvis and thighs, and falsetto voice.

Treatment.—In favorable cases the organ can be liberated, some supplementary plastic work usually being necessary. If the organ is rudimentary or there is complete hypospadias or congenital shortening of the corpus spongiosum, but little can be done.

Rudimentary Penis (Micropenis).—This abnormality is said to exist when the organ is less than two inches in length. It is generally associated with other abnormalities of the sexual organs, but may occur in those who are otherwise well developed. Cryptorchidism is a frequent complication. A penis that has remained in an infantile condition until

adolescence is likely to remain undeveloped throughout life. A reversion from the male type is occasionally seen, manifesting itself in unusual breast development, absence of hair on body or face, and a soft, effeminate voice.

Treatment.—A penis that is unusually small at birth requires no treatment: development generally takes place at the time of puberty. In young adults the organ may attain normal proportions when physical activity is established.

Various forms of apparatus have been devised for developing the

FIG. 254.—HYPERTROPHY OF THE PENIS WITH MULTIPLE PAPILLOMA.

organ, and although in several instances gratifying results were obtained, in others no benefit followed their use.

Megalopenis.—Occasionally the penis is so large as to prevent coitus and be a source of annoyance and discomfort to its possessor.

There is no *treatment* for this condition.

Double Penis.—Cases of double penis have occasionally been reported. The records show that urine can be discharged from either organ, and that both can be employed in coitus.

Tumors of the Penis.—Tumors of the penis differ in no essential way from similar growths in other portions of the body. They may be either benign or malignant. Those most frequently encountered are

papilloma and carcinoma. A few cases of lipoma, adenoma, angeioma, chondroma, and osteoma have been reported.

Papillomata, or **warts,** are more frequently seen on the external genitals of the male than on those of the female. The soft moist variety is the form most usually encountered in children and young adults. The tendency to their development decreases after middle life. When they occur in the aged, they are generally of the dry, hard variety, and are extremely likely to undergo malignant changes, resulting in the development of a *papillomatous carcinoma.*

Papillomata may be single or multiple in number, the latter being the most common. The tumors may be sessile or pedunculated. When associated with a phimosis, they may assume enormous proportions, finally causing a perforation of the prepuce with protrusion of the glans.

Treatment. — Cleanliness is absolutely essential. In recent small growths lactic acid is almost a specific. The tip of each wart should be touched with the acid once daily. In all other cases excision should be performed after the manner described on p. 489.

Elephantiasis of the penis has been fully considered in another chapter (Vol. II, p. 595).

Sarcoma.—This is the most serious of the tumors involving the penis. Unfortunately, the condition has made considerable progress before its true nature is suspected. It may occur either primarily or secondarily, the former being the most common.

FIG. 255.—CARCINOMA OF THE PENIS.

The tumor usually originates in the erectile tissue, grows with great rapidity, and may reach the size of a fetal head. The surrounding structures rapidly become involved. In about one-half the cases the inguinal glands are affected. The mass finally fungates, and ulceration with hemorrhage occurs. Pain is intense, and frequent erections add to the distress of the patient; in the later stage, priapism is not unusual.

Death occurs in from ten months to two years.

The *prognosis* is dependent on an early recognition and on prompt surgical intervention.

Treatment is operative, and consists of amputation or complete ex-

tirpation of the organ. In inoperable cases palliative measures must be resorted to.

Carcinoma.—A few cases of medullary carcinoma have been reported, developing in young adults, usually as the result of injury. Scirrhus is one of the rarest, and epithelioma one of the commonest, forms of malignant tumors involving the organ.

Among the predisposing causes may be mentioned want of cleanliness; chronic posthobalanitis; neglected papillomatous growths; phimosis, especially in men of advanced years. Not infrequently epithelioma has developed as the result of traumatism; it may also originate

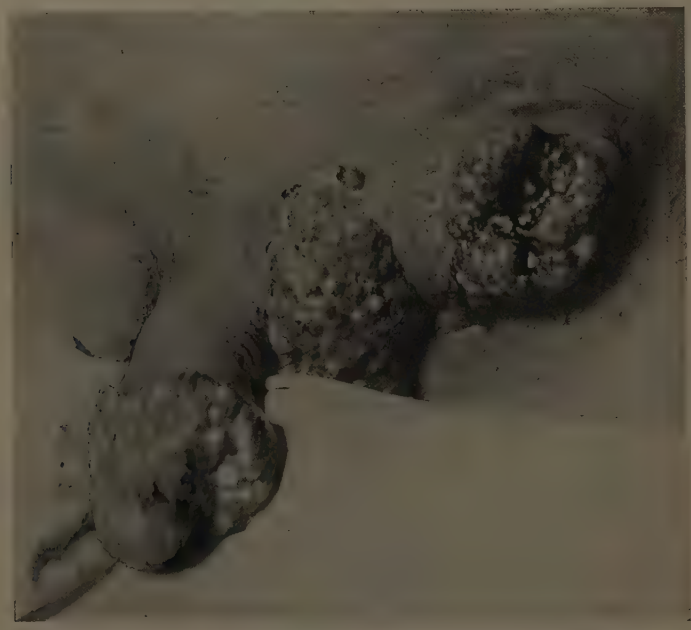

FIG. 256.—INOPERABLE CARCINOMA OF THE PENIS. DURATION SIX MONTHS, SHOWING UNUSUAL MALIGNANCY.

in an old cicatrix left by a chancre or a chancroid, and at the site of healed syphilitic ulcers.

It usually appears first upon the epithelial reflection of the prepuce, in a sebaceous gland, or on the dorsal aspect of the glans, about the corona. It has a tendency to remain localized for some time before attacking the body of the organ. The "precancerous stage," in which a chronic inflammatory process rebellious to treatment exists, may persist for from a few weeks to two years before typical symptoms of malignancy present themselves. The growth usually develops superficially, but may arise in the deeper structures of the organ. The lesion is indolent, tends to persist, and does not yield to treatment.

The *symptoms* of carcinoma vary in different cases according to the

age of the patient, the nature of the exciting cause, and the existence of complications.

A secondary carcinomatous growth, developing in the lymphatics and involving the cavernous bodies, is sometimes encountered, originating from a primary epithelial carcinoma of the distal extremity of the organ (Fig. 256). Such tumors have a tendency to burst through the cutaneous sheath and appear as large cancerous masses.

A positive diagnosis cannot be reached without a microscopic examination. As a rule, the glands of both groins are diseased at the time the patient comes under the surgeon's care. Constitutional effects manifest themselves at various times during the course of the affection, but not unusually the physical condition remains excellent even in the advanced stage of the disease.

The *prognosis* depends on early recognition of the character of the affection and on prompt surgical interference.

Treatment consists in early radical operation. When the glands alone are affected, I make it a rule to amputate at about the middle of the organ. If the cavernous bodies have become infiltrated, extirpation should be performed. Any associated enlarged glands should be extirpated. (For the technic of these operations see p. 490.)

OPERATIONS UPON THE PENIS.

Circumcision.—The instruments required are four hemostatic forceps; a sharp-toothed dissecting forceps; circumcision forceps; straight, blunt-pointed scissors and scissors with curved blades; a small straight needle threaded with a long strand of fine gut, and four fine catgut ligatures.

The field of operation is rendered sterile. The prepuce is grasped, by means of a pair of catch forceps, directly in the median line, on the upper and lower margin of the mucocutaneous junction.

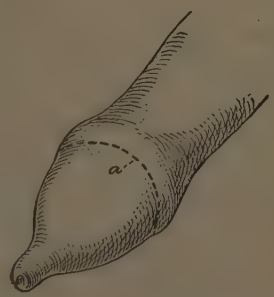

FIG. 257.—CIRCUMCISION, SHOWING THE PORTION (*a*) OF PREPUCE TO BE INJECTED WITH COCAIN.

The tissues are put on the stretch and drawn forward as far as required, and the circumcision forceps adjusted. When the blades of the forceps are closed on the foreskin, they should be parallel to the line *made by the corona glandis*, when they will be in a position oblique to the axis of the penis. The foreskin is next dissected away by means of scissors, just above and close to the blades of the circumcision forceps; the latter are then removed. It will now be found that the glans is covered by the mucous layer, which is divided in the median line, throughout its entire length, with scissors. The flap of mucous membrane on each side of the glans should be seized at the upper and lower angle by an assistant with hemostatic forceps, and then trimmed away by the surgeon. At least one-eighth of an inch should be left for the application of sutures. Bleeding

vessels should be ligated, and skin and mucous membrane approximated by means of interrupted catgut sutures. A dressing should be applied, consisting of a narrow strip of sterilized gauze folded upon itself three times to make slight pressure. *Only the suture line is covered,* the meatus being left exposed. The dressing should be kept constantly saturated

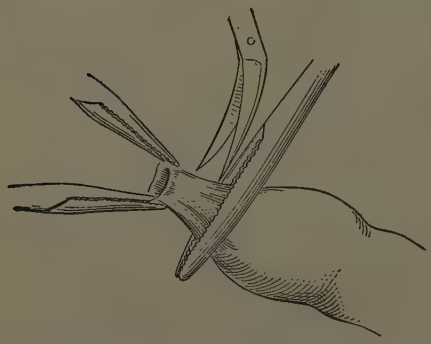

FIG. 258.—CIRCUMCISION. PREPUCE DRAWN FORWARD; APPLICATION OF CIRCUMCISION FORCEPS PARALLEL TO THE CORONA GLANDIS.

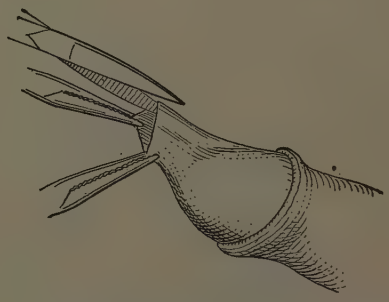

FIG. 259.—CIRCUMCISION. SKIN REMOVED, MUCOUS MEMBRANE DRAWN FORWARD AND DIVIDED ON THE DORSUM.

with lead-water and laudanum, and should not be changed for twenty-four hours.

Operation for Paraphimosis.—If seen soon after the accident, the parts can usually be restored to their normal position by taxis. If there is much distention from effusion of serum, the latter should first be evacuated by making small punctures in the integument. The surgeon grasps the organ with the left hand and supports it firmly, while

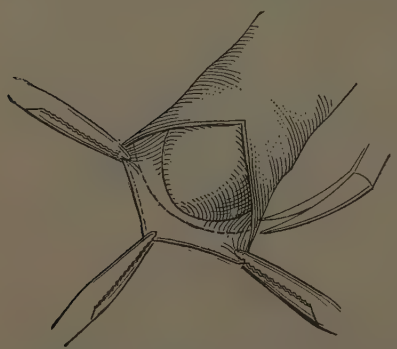

FIG. 260.—CIRCUMCISION. DIVIDED MUCOUS MEMBRANE DRAWN FORWARD AND TRIMMED AWAY PARALLEL TO THE CURVE OF THE CORONA.

FIG. 261.—CIRCUMCISION. COMPLETION OF OPERATION; APPLICATION OF SUTURES.

with the thumb and first two fingers of the right hand he squeezes out as much blood as possible from the head of the penis; with the hand holding the organ he attempts to push the prepuce back into place. If restoration cannot be effected, the constricting band should be divided with a curved bistoury on the dorsum in the median line. In long-standing cases it will be found impossible to restore the prepuce to its normal position.

Operation for Incurvation of the Penis.—When an incurvation is due to some constricting band affecting the cavernous bodies, the operation suggested by Physick may be employed. An incision one inch in length is made in the median line, beginning just back of the glans, dividing the structures down to the fibrous sheath of the corpus spongiosum. A wedge-shaped portion of the cavernous tissue is excised just a few lines behind the head of the penis. The V-shaped incision extends down to the *corpus spongiosum*. The amount of erectile tissue should be just sufficient to overcome the deformity. Bleeding vessels should be ligated and the cut edges of the fibrous sheath of the corpora cavernosa approximated by buried catgut sutures, after which the wound in the skin should be closed and a moist cold antiseptic dressing applied.

For the relief of a downward deformity associated with a hypospadias Duplay advocates making one or more transverse incisions upon the

FIG. 262.—DIVISION OF THE CONSTRICTING RING IN PARAPHIMOSIS.

under surface of the penis, completely dividing the constricting bands, incising the corpora cavernosa deeply if necessary. The two extremities of the wound are united first by means of fine silk sutures, after which the edges are approximated in the usual manner, the suture line being placed longitudinally.

Excision of Extensive Papilloma of the Penis.—If phimosis exists, circumcision or division of the prepuce on the dorsal aspect in the median line must first be performed. A rubber band is fastened securely around the base of the penis, to control hemorrhage. The surgeon grasps the penis firmly in the left hand, an assistant holding the glans with a pair of catch forceps; by means of the scissors with curved blades one mass after another is rapidly excised, the incision being made as low down on the base of the tumor as possible. The entire cut surface is touched with the dull red cautery, and the wound dressed with iodoform gauze so applied as not to cover the meatus.

Ligation of the Dorsal Artery or Vein of the Penis.—The dorsal artery may require ligation because of injury or disease, and for the relief of a form of impotence caused by too rapid return of the venous blood. When attempting to ligate the artery care must be observed not to injure the vein or nerve; when a ligature is to be passed around the vein, the artery should be shielded. A median incision three-quarters of an inch in length is made two inches in front of the pubic bone. After dividing the skin and superficial fascia the superficial dorsal vein is exposed, and must be carefully pushed aside to avoid injury. The groove of the corpora cavernosa is sought, and the layer of fascia cover-

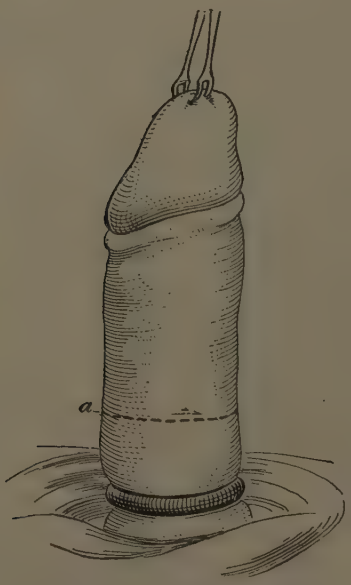

FIG. 263.—AMPUTATION OF THE PENIS.
Putting penis on stretch and application of tourniquet: *a*, Line of incision.

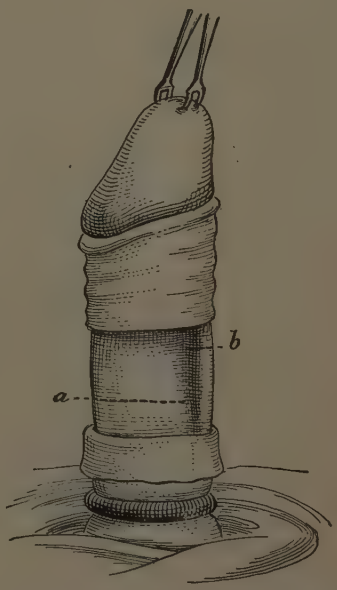

FIG. 264.—AMPUTATION OF THE PENIS.
Circular incision of skin and fascia of penis with formation of flap: *a*, Point of incision through the corpora cavernosa; *b*, point of incision through the corpus spongiosum.

ing it is carefully divided with the grooved director, when the artery, accompanied by the vein and nerve, will be exposed and may be ligated.

Amputation.—The galvanocautery has now, fortunately, fallen into disuse. There are two recognized methods of amputation, the one by an anterior and posterior, and the other by a circular flap operation. Of these, the latter is to be preferred. A metal bougie is inserted into the urethra. If a phimosis exists, the prepuce should first be laid open, in order that the tumor may be inspected and the diagnosis verified. The glans penis is now caught with catch forceps and pulled forward, being then passed to the assistant who holds the bougie. With a sweep of the knife a circular incision is made well back of the diseased tissue, completely encompassing the organ, and dividing the skin down to the fibrous

structure of the cavernous bodies. The skin-flap is then dissected back until it is of sufficient length to form a comfortable, roomy covering for the stump. The corpora cavernosa are next divided down to the corpus spongiosum, after which the urethra is dissected free from its attachment to the organ for a distance of at least a quarter of an inch in advance of the point at which the cavernous bodies were severed, care being taken not to injure the canal, after which the spongy body containing the urethra is divided, which will result in the corpus spongiosum being slightly longer than the stumps of the corpora cavernosa.

The dorsal artery and veins are ligated and the tourniquet is removed; a gush of blood from the erectile tissue generally follows, but, as a rule, the bleeding ceases almost immediately. Occasionally the cavernous arteries will require ligation. The urethra is now divided for at least one-quarter of an inch on the floor of the canal. The skin is pulled over the end of the stump, and two interrupted sutures are applied, one at each

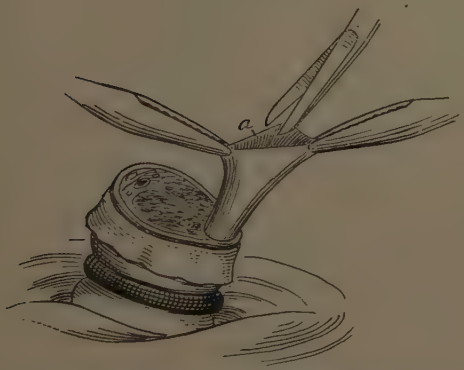

FIG. 265.—AMPUTATION OF THE PENIS.
Division of corpora cavernosa with dissection of urethra; showing division of the urethra (*a*) on the floor with formation of a fan-shaped flap.

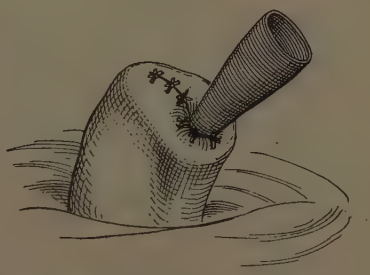

FIG. 266.—AMPUTATION OF THE PENIS.
Completion of operation.

corner. The urethra is next sutured to the margin of the skin, so that when the operation is completed, the urethral opening is spread out and has a large roomy orifice. A soft-rubber catheter is inserted, and continuous drainage established until union takes place.

Extirpation of the Penis.—If there is glandular involvement, the glands are first removed, after the following manner, suggested by Curtis. An incision is begun on one side, parallel to Poupart's ligament, and continued across the pubic bone to the groin of the opposite side. An upper and a lower skin-flap are dissected a little distance beyond the diseased glands. The incision is then carried downward until the fascia of the external oblique is reached, after which the entire mass of fat and glands is dissected free from the abdominal fascia until Poupart's ligament is reached. The same procedure is instituted below as was carried out above. Beginning below the mass and working upward, the fat and glands are dissected free from Scarpa's space. The upper and lower dis-

sections are continued until they meet at Poupart's ligament. The opposite groin having been treated in a similar manner, the surgeon pro-

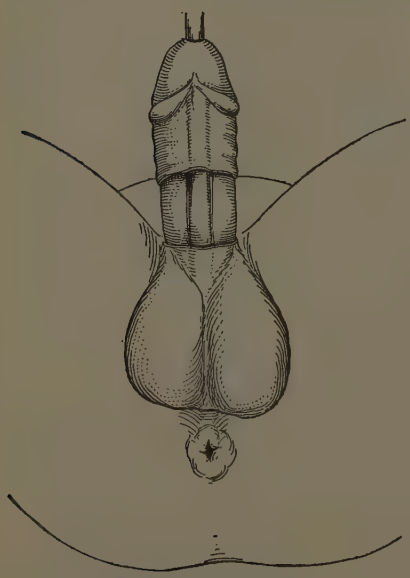

FIG. 267.—EXTIRPATION OF THE PENIS, SHOWING CIRCULAR INCISION OF SKIN AND FASCIA AROUND THE BODY OF THE PENIS AT THE PENOSCROTAL JUNCTION.

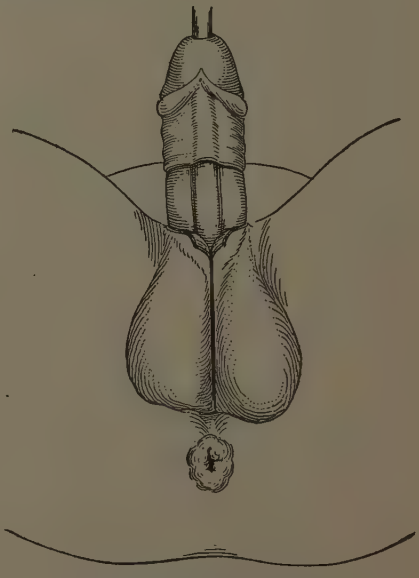

FIG. 268.—EXTIRPATION OF THE PENIS. INCISION SEPARATING THE TESTICLES.

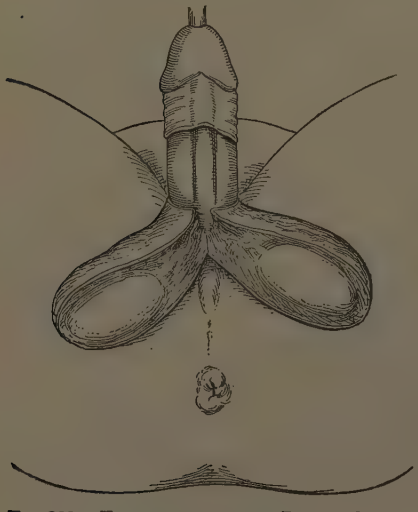

FIG. 269.—EXTIRPATION OF THE PENIS. THE TESTICLES SEPARATED.

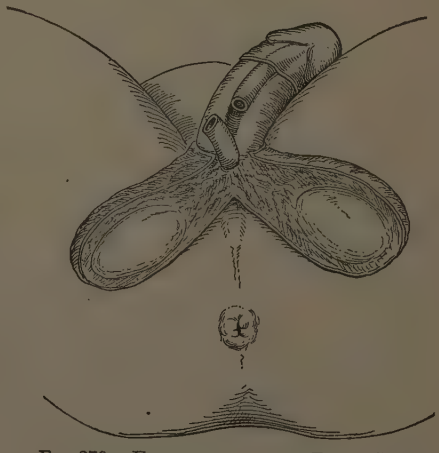

FIG. 270.—EXTIRPATION OF THE PENIS, SHOWING DISSECTION OF URETHRA.

ceeds to extirpate the organ. The patient is placed in the perineal lithotomy position. A steel bougie is inserted into the urethra. An incision

is made along the raphé of the scrotum from the root of the penis down to the perineum. By the aid of scissors and blunt dissection the scrotum is divided in the middle line, separating the tunica vaginalis, each con-

FIG. 271.—EXTIRPATION OF THE PENIS. DIVISION OF SUSPENSORY LIGAMENT AND EXPOSURE OF THE CRURAL ATTACHMENTS TO THE PUBIC BONE.

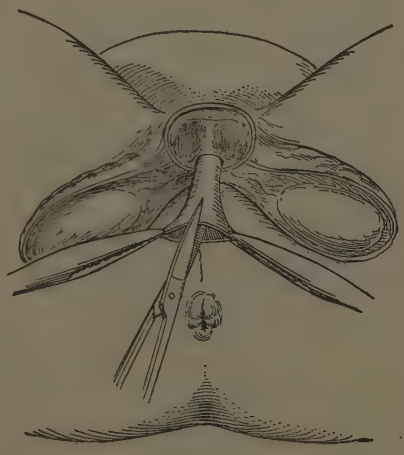

FIG. 272.—EXTIRPATION OF THE PENIS. COMPLETE EXTIRPATION WITH URETHRA PULLED DOWN AND DIVIDED ON THE ROOF TO MAKE A FAN-SHAPED FLAP.

taining a testicle, which is held aside until the corpus spongiosum is freely exposed at the bottom of the wound. The corpus spongiosum is next dissected free from its attachment to the cavernous bodies. The urethra is freed, if necessary, as far back as the anterior leaflet of the triangular ligament. The bougie is removed, and the urethra cut across and placed to one side until the succeeding steps of the operation are completed. A circular incision that completely surrounds the root of the penis and divides the skin down to the fibrous sheath of the penis is now made.

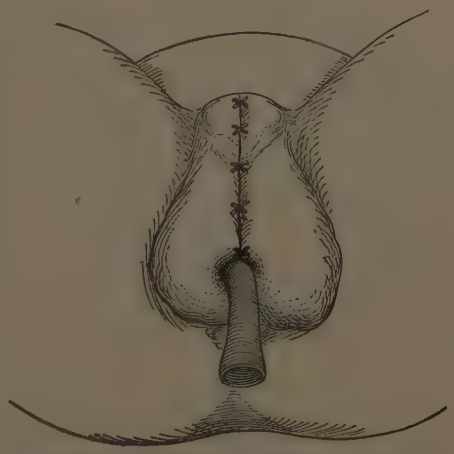

FIG. 273.—EXTIRPATION OF THE PENIS. OPERATION COMPLETED.

The skin-flap is pushed back toward the pubes, the suspensory ligament divided, and the cavernous bodies detached until only those of the crura remain, which are severed in turn. This procedure may be rendered bloodless by employing the angiotribe devised by Downes. All bleeding vessels being controlled, the detached penis, together with the mass of

fat and glands that is still attached to the organ by a pedicle consisting of fat and lymphatic vessels, is removed *en masse*. The skin wound is closed by interrupted silkworm-gut sutures. The urethra is split on its under surface for at least half an inch, and fastened to the skin surface as far anteriorly as possible. A soft-rubber catheter is inserted and allowed to remain until the sutures are removed on the seventh day. A light antiseptic dressing is applied.

SURGERY OF THE URETHRA.

URETHROSCOPY.

The direct visual examination of the urethra is accomplished with the aid of the urethroscope. One of the most satisfactory of the various forms of this instrument that have been devised is that equipped with Koch's tube, which is so arranged as to admit the light and at the same time permit the application of medicaments to any portion of the urethra.

A most satisfactory and useful form of endoscopic tube for examining the posterior portion of the urethra has been perfected by Swinburne; it permits inflammatory changes in the membranous and prostatic portions to be easily seen. The Marks instrument is useful in those cases in which the urethra is to be distended with air before the examination is made. The endoscope exposes to view only a small portion of mucous membrane, which appears at the terminal orifice of the tube; by moving the tube forward and backward, however, the entire canal, from the beginning of the posterior urethra to the meatus, may be inspected.

Endoscopic tubes are provided with obturators that close the orifice at the end of the instrument, thus facilitating the introduction of the tube into the urethra. The surgeon who desires to acquire skill in the use of the endoscope must first familiarize himself with the picture of the normal urethra as seen through the instrument. With the aid of the urethroscope the surgeon is enabled to diagnose and treat locally chronic inflammatory lesions of the urethra and processes involving the lacunæ of Morgagni or Littré's glands; by its aid, also, he can remove polypi, calculi, and foreign bodies from the urethra, and by means of it he may occasionally discover the position of the opening in a stricture of small caliber.

When making an examination of the urethra for the purpose of ascertaining whether inflammatory changes have taken place, the observer must first learn whether or not the normal elasticity of the canal has become impaired. In the healthy urethra the walls of the canal are thrown into folds as the endoscopic tube is withdrawn, whereas in cases of long-standing urethritis the canal becomes rigid and will be found to be non-dilatable at points, these changes being generally due to peri-urethral cell infiltration. The pathologic change next to be sought for is a deviation from the normal vascularity of the urethra. Localized well-defined areas of congestion, known as "congested patches," are often found near the fossa navicularis and in the region of the penoscrotal

junction. These are always associated with chronic catarrhal urethritis. A congested patch that becomes covered with pin-point-sized, velvety, papillomatous growths is known as a "granular patch." These lesions

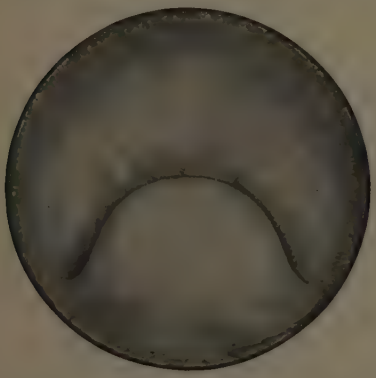

FIG. 274.—PROSTATIC URETHRA, UPPER PORTION (Stern).
One and one-half cm. below internal urinary meatus.

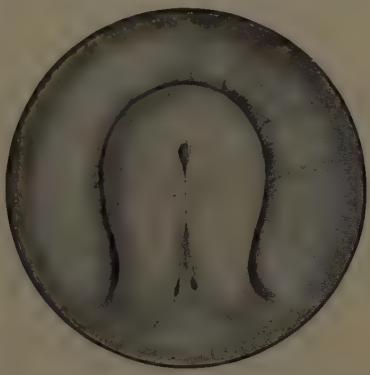

FIG. 275.—PROSTATIC URETHRA, MIDDLE PORTION (Stern).
Caput galli and sinus pocularis with orifices of ejaculatory ducts.

are usually about the meatus and on the floor of the urethra. The condition sometimes follows as the result of instrumentation.

The normal luster of the urethral mucous membrane becomes altered as the result of chronic inflammatory conditions, and any deviation should be carefully noted. Superficial erosions and ulcerations are oc-

FIG. 276.—PROSTATIC URETHRA, LOWER OR PRE-PROSTATIC PORTION (Stern).
Gradual depression of crista galli.

FIG. 277.—MEMBRANOUS URETHRA (Stern).

casionally observed. When they occur, they are usually situated near the meatus or in the prostatic urethra. Fenwick describes a condition, frequently seen, in which white, sodden-looking patches of epithelium, which he terms "nacreous patches," stand out in marked contrast to

the surrounding healthy-looking mucous membrane. This condition always indicates peri-urethral cell infiltration.

Normally, folds of mucous membrane are found at the bulbous portion of the urethra—principally on the floor. A chronic urethritis attacking

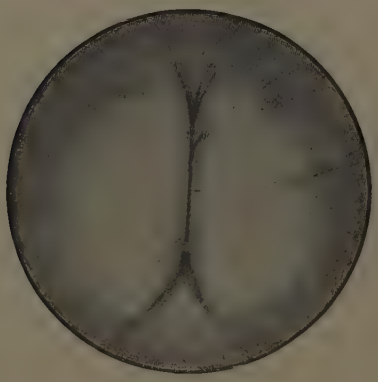

FIG. 278.—BULBOUS URETHRA (Stern). Vertical slit-shaped lumen anterior to triangular ligament.

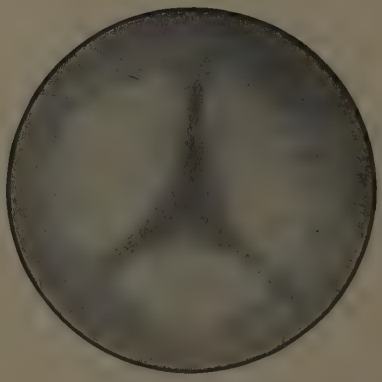

FIG. 279.—PERINEAL PORTION (Stern). Triangle-shaped lumen.

the bulbous urethra causes swelling and edema of these folds—a condition always associated with the most intractable form of gonorrhea.

The lacunæ magnæ are usually readily detected by the urethroscope, but, in the normal condition, the orifices of the ducts of Littré are not

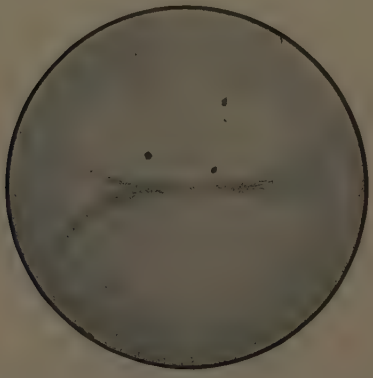

FIG. 280.—PENOSCROTAL JUNCTION (Stern). Horizontal slit-shaped lumen. Glands of Littré.

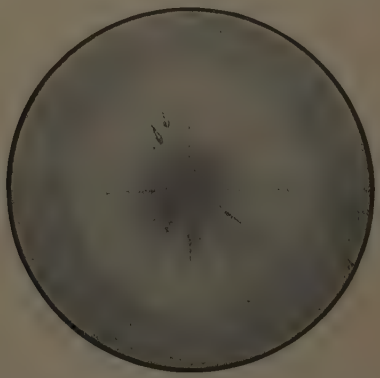

FIG. 281.—PENDULOUS URETHRA (Stern). Round lumen. Follicles of Morgagni.

discernible. The mouths of the ducts which lead down to Cowper's glands cannot be seen without the aid of an aëro-urethroscope.

In examining the posterior urethra the degree of congestion present and the existence of superficial erosions or ulcerations should be determined. Rigidity and thickening of the verumontanum and the ap-

pearance of the mouths of the prostatic and ejaculatory ducts should also be noted. A urethroscopic examination will determine definitely whether or not a stricture of large caliber exists, and in strictures of small caliber it may serve to show the position of the opening through the coarctation.

MALFORMATIONS OF THE URETHRA.

Hypospadias is a congenital defect of the anterior urethra believed to result from arrested fetal development.

Varieties.—The classification of the various forms is based on the extent and character of the deformity and on the position of the opening; thus we have glandular or balanic, penile, and scrotal hypospadias.

The simple uncomplicated form of *glandular hypospadias* causes but little discomfort. The prepuce frequently participates in the deformity or it may be absent; it is most commonly found to be either separated or absent on the posterior surface.

The *penile* form of hypospadias is a more serious deformity than the glandular variety. The urethral orifice may be situated somewhere on the under surface of the penis, from just back of the glans to the scrotal portion of the canal. The urinary outlet is just behind the base of the glans, at the middle, or at the scrotal portion of the anterior urethra. When the urethra is intact as far as the glans, the penis, although smaller than normal, is usually a fairly well-developed and a very useful organ. The extent of malformation of the associated genital organs is usually in direct proportion to the degree of urethral defect present.

In *scrotal hypospadias* and *perineal hypospadias* the penis is generally stunted, and the glans may be broadened and strongly curved downward toward the scrotum. On raising the organ a funnel-shaped opening, lined with mucous membrane, will be discovered, in the deepest portion of which is a vertical slit—the urethral outlet. A deep cleft divides the scrotum into two lateral halves, each of which may contain a normal testicle. If, however, the testicles have failed to descend, the scrotal sacs will be empty. Incontinence of urine is very seldom associated with hypospadias.

Treatment.—The treatment of the simpler forms and of some specially selected cases of hypospadias consists in the performance of a series of plastic operations. In any case, good results are obtainable only with great difficulty. In the scrotal varieties surgical treatment can accomplish nothing. In every case the ultimate outcome is merely conjectural; in selected cases, nevertheless, the time and labor expended will frequently be rewarded by a brilliant result. I have found that, in children, the best time to perform the preliminary operation is when the child is about four years of age; this consists in separating adhesions between the penis and scrotum and in straightening the organ, and has been fully described on p. 489.

Operation.—The first stage consists in making an effort to correct the curvature of the organ and in freeing scrotal adhesions, at the same

time restoring the glandular portion of the urethra. When the patient has convalesced from the first operation, perineal drainage is instituted and an effort is made to restore the missing portion of the urethra, and, finally, the continuity of the urethra is established by closing the distal and proximal opening of the canal by means of flaps obtained from the skin of the penis and scrotum. Usually several operations are necessary before this is accomplished.

When the glandular urethra is represented by a deep furrow, the restoration of the portion of the canal that traverses the glans is accomplished by freshening the lower margins of the glans on each side sufficiently to give two raw surfaces that will be broad enough, when approximated by means of interrupted sutures, to assure firm union. Into the furrow is placed a short section of a catheter, which is left *in situ* for four days, the new urethra being formed over this.

If the urethral furrow is very shallow, or appears to be absent, the lower edges of the glans are freshened on each side. In order to form a urethral groove an incision of the required depth may be made the entire length of the glans, or two small lateral incisions, extending deeply into the substance of the glans, may be made, and the lower part of the lips vivified; the final step consists in molding the urethra over a small section of a catheter and approximating the raw edges by means of a few interrupted fine silk sutures.

For the relief of a balanic hypospadias, or for those cases in which the urethral opening is situated a short distance from the base of the glans, Beck has devised an ingenious operation. He describes it as "a forward dislocation of the urethra. In place of forming a new urethra, the existing one is utilized by dissecting it free and dislocating it forward, so that a new canal does not need to be created, the existing urethra performing its function." The technic of his operation is as follows:

A catheter is inserted into the urethra until the bladder is reached, the leakage of urine being prevented by temporarily closing the outlet. A comparatively long silk suture is passed through the walls of the catheter and the orifice of the urethra; this is knotted and utilized at a later stage of the operation, when it is desired to fasten the urethral orifice to the tip of the glans penis. The catheter acts as a guide, puts the organ on the stretch, and also serves as a guide when dissecting the urethra free.

The isolation of the urethra is greatly facilitated by having the organ well extended while the dissection is in progress; this is best accomplished by fastening a thin wooden splint to the dorsum of the organ by means of gauze; the end of the splint, as well as the apex of the glans penis, is grasped with catch forceps and pulled forward. An incision is now made through the skin, down as far as the posterior third of the penile urethra. The glans penis is pulled forward, and a transverse incision is made through the cutaneous covering at the base of the glans; this should *encircle one-third of the neck of the penis*. The skin-flaps are now dis-

sected back until the lower third of the penis is laid bare. The flaps are well retracted, and the corpus spongiosum, containing the urethra, is dissected from its bed between the corpora cavernosa.

It now remains to establish a groove on the under surface of the glans, or a tunnel may be made through that structure for the reception of the dislocated urethra. This may be effected by pushing either a trocar or a narrow straight bistoury through the structure of the glans in the direction of the natural channel, dilating the canal thus constructed by means of forceps. Or a lateral incision may be made along the edges of the urethral groove, on the under surface of the glans, forming two flaps; the resulting cleft should be sufficiently deep and commodious to accommodate the transplanted portion of the urethra. Finally, the edge

FIG. 282.—BECK'S OPERATION FOR BALANITIC HYPOSPADIAS (Fowler). A, Lines of incision; B, tunneling for the urethra.

of the urethral orifice is grasped by means of a delicate pair of catch forceps, drawn up to the top of the glans, and anchored by means of four silk sutures. The flaps forming the glans are united around the urethra, and the lateral skin-flaps are likewise approximated. It is well to leave a catheter à demeure in place for a few days.

Various modifications of the technic for restoring the penile urethra have been suggested from time to time. Probably one of the most satisfactory methods is that devised by Thiersch, and originally employed by him for the relief of epispadias. He first frees the penis from any existing adhesions, corrects the curvature, and reconstructs the glandular urethra in the manner previously described, after which he endeavors to form the missing portion of the penile urethra.

Before attempting to restore the urethra, a preliminary external perineal urethrotomy is performed, and perineal drainage of urine is maintained until success of the plastic work is assured. For the formation of the penile urethra double flaps are required; these are taken from each side of the urethral groove. The flap that is to be uppermost is the one usually formed first. It is secured by making a three-sided rectangular incision close to and parallel with the urethral furrow, the length corresponding with the length of the portion of the urethra that is to be formed. This is illustrated by the line *a b* (Fig. 284) at the upper and lower ends of the incision; two short incisions are made at right angles to the first by *cutting backward away from the urethral groove*, as shown by the lines *b c* and *a d* (Fig. 284). This flap should be so broad

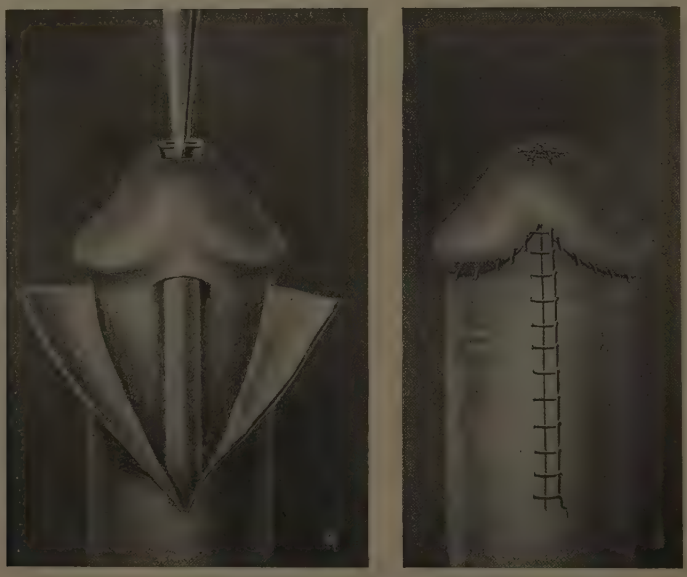

FIG. 283.—BECK'S OPERATION FOR BALANITIC HYPOSPADIAS (Fowler). A, Urethra in position; B, sutures applied.

that, when raised, it can be transposed to the line *g h* (Fig. 284). The flap of the opposite side is cut in a similar manner, except that the three-sided rectangular incision is reversed, the two short upper incisions being made in an exactly opposite direction to the corresponding ones on the other side, represented by the lines *e g* and *f h* (Fig. 284), and carried far enough back so that when they are joined by the incision *g h* a flap will be obtained that, when dissected up, will be equal to one and one-half times the diameter of the canal it is desired to form. After the flaps are formed it will be observed that the base of the lower flap, *e f g h*, lies directly along the edge of the new urethra, whereas the base of the other flap, *a b c d*, is some distance from the urethral groove. The flap *e f g h* is now turned over so that the cutaneous surface presents downward and the

raw surface uppermost, and is drawn over and fastened by means of three or four fine silk mattress sutures to the base of the line *c d* of the flap of the opposite side. The sutures passing through the base of the flap are tied on the outside (Fig. 284 *B'*). The second flap, *a b c d*, is now drawn over the first one and adjusted in such a manner that the denuded surfaces are brought into contact, and, provided there is not too much tension, sutured at the base line *g h* of the flap *e f g h*. If this is found to be impracticable, the edge of the flap should be sutured to any portion of the denuded surface to which it can be attached without producing excessive tension. When this stage of the operation is completed, it remains to close the small opening that may exist between the glandular and the penile portion of the newly formed canal, as well as the hiatus in

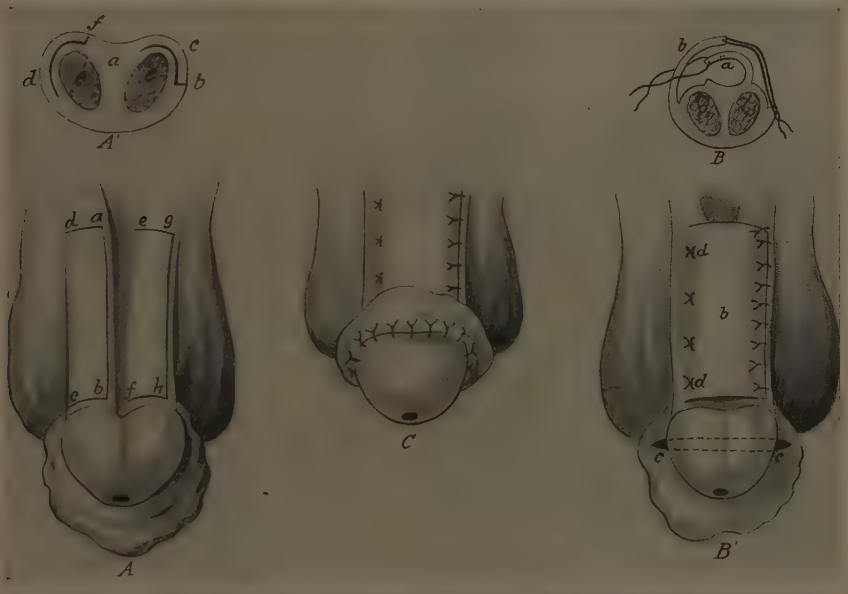

FIG. 284.—THIERSCH'S OPERATION FOR PENILE EPISPADIAS, THE GLANDULAR URETHRA HAVING BEEN RESTORED.

the region of the scrotum. If there is a redundant foreskin, the preputial tissue may be utilized in closing the opening that exists in the anterior portion of the canal. When the prepuce is undeveloped, a plastic operation, using such tissue as may be available, must be employed. The lower opening may be closed by means of a skin-flap taken from the scrotum.

Epispadias is a congenital deformity in which either a portion or the entire roof of the urethra is undeveloped. There are several degrees of this deformity: (1) The defect in the superior wall of the urethra may be limited to the glandular portion; (2) it may involve the penile portion; (3) it may involve the glandular and a portion of the spongy urethra; (4) it may implicate the anterior portion of the canal from the

meatus to the pubes. Thus we have glandular epispadias, penile epispadias, spongioglandular epispadias, and complete epispadias.

Symptoms.—The extent of impairment of the functions of the organ is dependent upon the type of epispadias present. In the *simple glandular* form, in which the organ is otherwise normally developed, coitus is interfered with but slightly. In *complete epispadias* incontinence of urine, either partial or complete, is the rule.

Treatment.—In *complete epispadias* the penis is rudimentary and the condition is, therefore, irremediable. A *simple glandular epispadias* with a deep cleft is easily corrected by means of a simple plastic operation. When the urethral groove is very shallow or absent, Curtis advocates cutting flaps from the glandular tissue, after the manner suggested by Thiersch* for the cure of the penile defect.

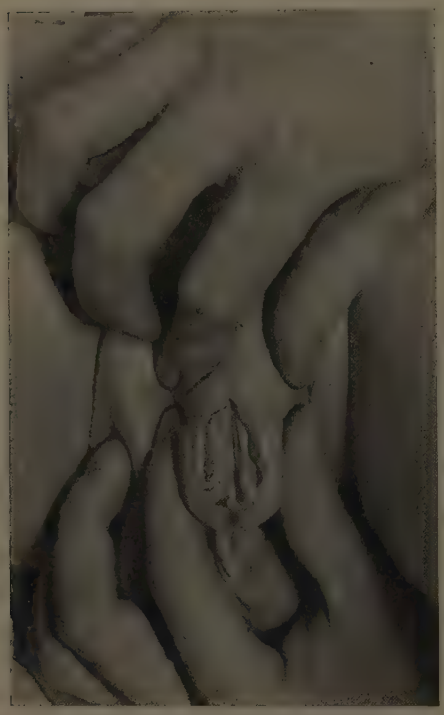

FIG. 285.—EPISPADIAS.

I have found the following method, suggested by Duplay, probably the most satisfactory operation that has been devised for the relief of these deformities.

The first step of the operation aims to free the penis from any adhesions that may exist, and to straighten the organ in the manner described on p. 489. After an interval of rest the second step is undertaken. As a preliminary measure, which assures the success of the plastic work, perineal drainage should be instituted and maintained until union of the raw surfaces brought into apposition to form the new urethra has taken place. Duplay takes advantage of the fact that the cavernous bodies, instead of being firmly united, are usually joined by a fibrous septum; thus, by depressing this septum by means of a glass rod or a catheter, the corpora cavernosa are brought into apposition and the cleft thus formed is utilized to form the floor and a portion of the sides of the new canal, the roof being constructed by approximating the denuded margins of the corpora cavernosa by means of a modified quilled suture. If the urethral furrow is very shallow or undeveloped, it becomes necessary to construct a groove that will correspond in length to the portion of the canal that is to be formed; it should be of sufficient

*"Amer. Text-Book G. U. Dis.," p. 24.

depth comfortably to accommodate a rubber catheter at least 15 mm. in circumference. To accomplish this a median incision should be made directly between the cavernous bodies, the length and depth of which should be sufficient, when the roof of the canal is constructed, to form a commodious urethra.

Fig. 286.—Complete Epispadias.

The urethral roof is formed by taking a parallel rectangular strip of tissue, about one-fourth of an inch in width, from each side of the corpora cavernosa, and three-fourths of an inch from the mid-line of the dorsum of the penis, extending from the apex of the glans penis down to the epispadic opening. The denuded surfaces, together with the points for sutures, are shown in Fig. 289. The raw surfaces are now brought into apposition by means of modified quilled sutures. For this purpose a plate composed of lead or hard rubber or a section of catheter in which holes, one-fifth of an inch apart, have been pierced for the passage of the sutures, may be employed; this, when adjusted, serves not only to hold

Fig. 287.—Formation of New Canal. Shows raw surfaces and position of sutures.

Fig. 288.—Modified Quilled Suture.

the raw surfaces firmly in contact until union takes place, but also acts as a splint to maintain the part at rest. A plate of the same length as the rectangular denuded area is placed on each side of the vivified surfaces, and the freshened edges of the two sides are carefully approximated by means of fine silver wire sutures passed through the holes in the plates from one side to the other, the splints being maintained in position by slipping over the wire, on both sides, perforated shot that are pushed along the wire until the plates are reached, where they are clamped.

The quilled suture is removed on the seventh day, and perineal drainage is discontinued. As the distal portion of the urethra terminates in close proximity to the epispadic urethral outlet, the formation of a junction between the new urethra and the epispadic opening is usually accomplished by vivifying the margins on each side of the infundibuliform epispadic outlet, as well as the edges of the termination of the new urethra; the freshened edges are then firmly approximated either by means of silkworm-gut sutures or the modified quilled suture. In some instances the attempts to close the canal will be only partially successful, and minor plastic operations will become necessary.

CONTUSIONS, WOUNDS, AND INJURIES OF THE URETHRA.

A *contusion* involving the urethra alone is not common; when it does occur, it is usually due to direct violence, or may follow careless instrumentation. A few cases of *subcutaneous contused wounds* have been observed in which the skin remained uninjured, but the structure of the penis and the urethra were crushed. This is always a serious accident.

Injuries inflicted directly on the urethra usually assume the form of either a contused or a lacerated wound, such as might be inflicted by foreign bodies or by the passage of a small, rough stone from the bladder along the canal; or the injury may take the form of a "false" passage, caused by the manipulation of urethral instruments.

Incised wounds, other than those made by the surgeon, are extremely rare. *A punctured wound* is the result either of an attempt at self-mutilation or of assault. *Gunshot wounds* of the canal are usually associated with injury to other structures or organs.

Rupture of the urethra occurs as the result of violence or is due to pathologic changes accompanying stricture. When the rupture is due to traumatism, the laceration is usually situated near the bulbomembranous junction. Rupture has been known to be associated with fracture of the bones of the pelvis, and it may also be the result of forcible attempts at depressing the organ when erect; it may likewise result when the turgid penis is brought into violent contact with the pubic bone of the female in attempts at coitus.

Symptoms.—The symptoms are dependent upon the cause and upon the character of the injury. A *simple contusion* of the canal, such as frequently follows urethral instrumentation, usually gives rise to a sore, bruised feeling at the site of the injury, the discomfort being increased by motion,

urination, or erection. The symptoms of *incised*, *lacerated*, *punctured*, or *gunshot wounds* vary in degrees of severity in different cases, being dependent on the extent and character of the injury and on the portion of the canal that is wounded. There may be swelling, pain, and hemorrhage, together with difficult urination or retention or extravasation of urine. If the urethra has been penetrated from without, urine may escape through the new outlet. Swelling seldom occurs unless rupture of the canal has taken place or damage has been inflicted on neighboring structures. It usually makes its appearance about twenty-four hours after the accident, increasing slowly, and it may involve the pendulous, deep urethra, or the perineum. Swelling of sudden onset that rapidly invades the perineum, scrotum, or penis, associated with retention of urine, is significant of rupture of the urethra. The blood loss may vary from a few drops to a severe hemorrhage, that may continue for several days if not properly controlled. In incised wounds or in superficial lacerations of the mucous membrane of the anterior urethra the blood flows in a small continuous stream, being uninfluenced by urination. In partial rupture of this portion of the canal only a few drops of blood may appear, the hemorrhage being increased by the act of urination, and the *blood preceding the urine*. It is not uncommon, in laceration of the mucous membrane, for slight hemorrhage to cease until urination is attempted, when a good-sized clot of blood will be discharged and the hemorrhage recur. When the deep urethra has been injured, the blood likewise precedes the flow of urine; if, however, retention has occurred, the blood flows back into the bladder, mixes with the urine, and when the latter is discharged, it presents the bright scarlet color of arterial blood. Unless the urethra has been ruptured, the function of urination is seldom interfered with until twenty-four hours after the injury; by this time spasm, the result of the local inflammatory process at the site of the wound, together with edema of the mucous membrane, so narrows the lumen of the canal as to make urination difficult or impossible. Pain is not, as a rule, a very troublesome symptom. When, however, it is caused by laceration of the mucous membrane as the result of instrumentation in the presence of some inflammatory process involving the urethra, prostate gland, or bladder, it may be severe. Recurring painful erections not infrequently constitute a troublesome symptom.

Treatment.—*Simple contusions* demand but little treatment. A cooling, sedative lotion may be applied, and such remedies as have a tendency to render the urine bland and to allay sexual excitement should be prescribed.

In the treatment of *wounds of the urethra* the indications are: (1) To control hemorrhage; (2) to relieve retention of urine when this exists; (3) to prevent extravasation of urine by instituting perineal drainage early; (4) to dress the wound, when external and communicating with the urethra, with an appropriate aseptic dressing, and, at the same time, to attempt to render the urine sterile by administering proper remedies; (5) to relieve pain and allay sexual excitement.

If an external wound communicating with the urethra exists, the

edges should be approximated by means of fine silk sutures, and continuous drainage established by inserting a catheter through the urethra into the bladder, allowing it to remain until union has taken place. In the presence of extensive wounds that involve not only the urethra, but the peri-urethral structures as well, or if extravasation of urine has occurred, immediate external perineal urethrotomy should be performed and free drainage established. A partial rupture of the penile urethra may be treated by means of continuous catheterism, provided there is no evidence that urinary extravasation has taken place; when the latter has occurred, however, perineal drainage should be instituted. When a complete rupture of the membranous urethra exists, perineal section should be performed, and the distal and proximal ends of the tube sought for; these should be approximated by means of interrupted, fine catgut sutures, a catheter à demeuere being left in place until union has occurred. In *gunshot wound* proper provision must be made for the escape of urine and wound secretions.

EXTRAVASATION OF URINE.

The occurrence of extravasation of urine always indicates that a **rupture,** either partial or complete, of some portion of the urethra has taken place. In partial rupture only the mucous or a portion of the muscular coat of the canal may be affected, or the rent may be merely a small opening permitting but a small quantity of urine at a time slowly to infiltrate the peri-urethral tissues. On the other hand, the tear may be extensive, or the urethra may even be completely severed; in either case extravasation rapidly takes place.

Rupture of the urethra may result from straining in the effort to urinate in cases of retention in which the walls of the canal have become softened as a result of long-standing pathologic changes, or it may take place behind a foreign body or a calculus impacted in the urethra. A partial rupture of one or more coats of the canal sometimes results from overdistention caused by the insertion of urethral instruments; occasionally it has been known to follow internal urethrotomy, but it is most commonly encountered as the result of a sudden giving way of the urethral wall behind a stricture of small caliber or as the result of traumatism.

The **symptoms** are both local and constitutional. A partial rupture of the mucous membrane and of some of the fibers of the muscular coat of the urethra as the result of instrumentation or of internal urethrotomy is attended by hemorrhage. The blood flows from the meatus in a small, continuous stream, and is uninfluenced by urination. The patient complains of a sore, bruised feeling, and dysuria and frequent micturition or complete retention occur.

A partial rupture or the denudation of a circumscribed area of the mucous membrane on the floor of the urethra, behind a stricture, permits a localized slow infiltration of a small amount of urine at a time to take place into the peri-urethral tissues. Plastic lymph forms at the

site at which leakage occurs. When the urine is sterile, an internal blind fistula forms, and on palpation a well-marked fibrous mass can be detected at the seat of the injury. When associated with strictures of small caliber near the bulbomembranous junction, the plastic exudate increases and the mass gradually becomes larger, projecting into the scrotum, between the testicles, or developing on one side of the perineum and scrotum. The inflammatory exudate gradually becomes organized into a tough, fibrous tissue that renders any attempt at performing an external perineal urethrotomy without a guide difficult. When infection of this plastic exudate takes place, the mass becomes inflamed and painful and increases in size; deeply seated suppuration also occurs. If the pus is not evacuated by means of an incision, an abscess will gradually form and rupture, leaving a fistulous communication with the urethra; this has been described by the older writers as a "*urinary abscess.*"

The rarest and gravest form of extravasation of urine accompanying rupture of the urethra is that in which the structure of the corpora cavernosa is invaded. In this the urine rapidly dissects its way forward until the glans is reached, leaving a septic inflammation in its wake. The glans becomes gangrenous.

A rupture of the pendulous urethra most frequently involves the common fascia of the organ, the urine rapidly extravasating over a large extent of surface. The penis becomes greatly swollen, misshapen, and painful, and has a hard, brawny feel. The urine finally reaches the scrotum, which in turn becomes edematous and inflamed.

In extravasation of urine from injury to the penile urethra early ulceration of the skin usually occurs, permitting drainage to take place, thus allowing the urine to escape before wide-spread extravasation and extensive damage can result. The condition is very different if the infiltrating urine comes from a rent in the bulb or the portion of the canal included between the attachment of the scrotum and the anterior leaflet of the triangular ligament or the membranous portion of the urethra. In such cases there is little hope of drainage being established by ulceration, and, consequently, if the condition is not promptly relieved by operative interference, a wide-spread gangrenous cellulitis results.

When the extravasation is due to an injury of that portion of the urethra included between the attachment of the scrotum and the anterior layer of the triangular ligament, a tumor will first be noticed in the upper portion of the perineum and lower portion of the scrotum; the swelling gradually extends until the entire scrotum is involved, the urine slowly dissecting its way up on the pubes and thence to the abdomen.

When extravasation follows as the result of an injury sustained by the membranous urethra, the urine first infiltrates the perineum. If the urine has been confined to the perineum for any length of time and the anterior leaflet of the triangular ligament gives way, the urine infiltrates the tissues in a manner similar to that which takes place when the bulb is implicated, and which has just been described. When the posterior leaflet yields, the symptoms are similar to those observed when the prostatic urethra is perforated. Most commonly the urine extends along

the course of the rectum, the tumor appearing in the anal region; it may infiltrate the subperitoneal connective tissue, giving rise to a pelvic cellulitis or peritonitis, or, as rarely happens, it may work its way upward around the prostate gland and neck of the bladder until it reaches the space of Retzius.

The gradual infiltration of urine into the peri-urethral tissues associated with the formation of a phlegmon or fistula is not attended by constitutional manifestations. When the extravasation occurs suddenly and extends rapidly over a wide area, grave general symptoms develop. When the urine is sterile, cellulitis or constitutional manifestations may be delayed for several days; when it is ammoniacal or contains putrefactive bacteria, gangrenous cellulitis, with all its violent local inflammatory symptoms, develops promptly. The systemic symptoms are similar to those of septicemia. If the local disturbance is not relieved, the patient's condition becomes grave. Marked exhaustion, a bounding pulse, quick, shallow respiration, irregular fever, a dry, glazed, cracked, and fissured tongue, constipation, wandering delirium, and, finally, coma, ensue.

Treatment.—When the infiltration of urine takes place gradually from a rupture behind a stricture of the urethra, giving rise to a peri-urethral inflammatory exudate, internal blind fistula, or abscess, the treatment consists in restoring the urethra to its normal caliber by a suitable operation. Abscesses should be opened and drained, and resulting fistulas must be closed by appropriate plastic operations. A partial rupture that involves the mucous and a few fibers of the muscular coat of the canal and is not attended either with constitutional symptoms or with signs of extravasation of urine may be treated by means of continuous catheterism until the injury sustained by the urethra has healed. Septic symptoms or evidences of urinary infiltration demand perineal drainage.

A rupture of any portion of the urethra included between the attachment of the scrotum and the posterior leaflet of the triangular ligament should be regarded as a grave surgical emergency. In such cases an external perineal urethrotomy should be performed as soon as the diagnosis is made, in order to prevent the development of gangrenous cellulitis or sepsis. In extensive infiltration of urine from a rupture occurring behind a stricture, perineal drainage should be established and the surgeon should proceed at once to restore the normal caliber of the canal. In a complete rupture of the membranous urethra due to traumatism an external perineal urethrotomy should be performed, and a full-sized, soft-rubber catheter should be inserted through the urethra into the bladder; the proximal and distal ends of the torn urethra should then be approximated by means of interrupted catgut sutures. In such cases it may occasionally be necessary to perform a suprapubic cystotomy and retrograde catheterism, in order to locate the distal end of the torn urethra. When the urine has infiltrated the perineum, scrotum, or penis, or has passed up on the abdomen, free drainage for the purpose of allowing egress of the urine and the removal of the gangrenous sloughs should be provided for; this

is best accomplished by making multiple incisions through the skin of the invaded structures. Three incisions into the scrotum, and two or three on the side and under surface of the penis are usually sufficient; on the abdomen as many incisions as may be necessary to insure free drainage should be made.

The indications, therefore, in treating a rupture of the urethra at any point from the attachment of the scrotum to the posterior leaflet of the triangular ligament are: To perform external perineal urethrotomy; to restore the normal caliber of the urethra by suitable operative measures; to provide for free drainage of the infiltrated tissues. If urine is extravasated from a rent in the membranous urethra, in which case the posterior layer of the triangular ligament ulcerates, or if there is a rupture of the prostatic portion of the canal, the urine works its way backward toward the pelvis, or in very rare instances it passes upward around the prostate gland and neck of the bladder until it reaches the prevesical space. A small amount of blood appears at the meatus, urination is difficult, and retention may occur. The perineum, rectum, and the region of the neck of the bladder are the seat of pain. The temperature is irregular, the pulse-rate is increased, and nausea and *constant vomiting* are present. As a result of the development of pelvic cellulitis or peritonitis the patient rapidly becomes septic.

If the urine finds its way to the anal region, an examination will reveal a pseudo-fluctuating swelling that is tender on palpation. The rectum feels hot and is sensitive to manipulation. When the urine reaches the prevesical space, the abdominal wall just above the pubic bone becomes rigid and tender; later on a marked swelling is discernible, associated with edema of the structure. When the urine extravasates posteriorly, perineal drainage must be instituted by means of incision, the dissection being carried well back, separating the prostate from the rectum in order to facilitate the evacuation of deep-seated pus or extravasated urine. If the space of Retzius is involved, an incision is made just above the pubic bone, and carried up along the median line of the abdomen as far as may be necessary; the dissection is then continued downward until the bladder is reached, being careful not to open the peritoneum.

The **constitutional treatment** is the same as that indicated in sepsis arising from other causes. Careful nursing, scrupulous attention to antisepsis, and stimulating and supportive treatment are indicated. Even in apparently desperate cases the outcome is often gratifying, provided perineal drainage is established, the caliber of the urethra restored, and exit provided for the escape of pus or urine from the infiltrated tissues.

FOREIGN BODIES IN THE URETHRA.

A foreign body reaches the urethra in one of several ways, but most commonly by being inserted or forced through the meatus. The body may descend through the urethra, as the result of muscular contractions and erections, until it enters the bladder, only to be forced back into the

urethra, there to lodge and give rise to obstruction; or it may descend from the bladder and be retained in some portion of the canal. In rare instances an obstructing body, such as a urethral calculus, will form in the urethra as the result of a tight stricture.

Symptoms.—The passage of small stones along the urethra is generally accompanied by discomfort and pain. In infants the first symptoms are urethral pain and dysuria or retention. In adults there is a history of renal colic or of vesical irritability, due to the presence of the calculus, preceding the urethral symptoms. The onset is frequently sudden, coming on during the act of urination. When the stone has entered the urethra, there is a constant desire to empty the bladder. The urine may be passed in drops, as a small stream, or complete retention may result. Slight urethral hemorrhage and frequent painful erections occur. The passage of the stone is attended by a tearing sensation and burning pain. The stone may be passed in the course of a few minutes or it may lodge in some portion of the canal, causing partial obstruction and symptoms analogous to those produced by tight stricture. Structural changes always take place in that portion of the canal behind the calculus.

The symptoms that occur after the introduction of a foreign body into the urethra vary greatly. In urgent cases there is usually severe burning pain. If the object is rough or sharp, there is a feeling as if the canal were being lacerated. There is a frequent and urgent desire to urinate. Complete retention is rare. The urine is generally voided in drops, or passes alongside of the foreign body in a small stream. Free hemorrhage is but seldom observed; as a rule, the blood dribbles from the meatus and is frequently mixed with urine. A fixed body rapidly gives rise to active inflammatory symptoms, whereas movable bodies tend to manifest late or no urgent symptoms. Urethritis appears sooner or later.

The symptoms, as a rule, are not severe unless the body is lodged in the posterior urethra. When the object is impacted in the anterior urethra, active inflammation follows; the penis becomes enormously swollen and of a vivid red hue, and violent pain and fever of the ordinary urethral type occur. When the foreign substance is lodged in the posterior urethra, the swelling and edema of the penis are much less marked, the perineum is tense and painful, and there is more severe dysuria or even strangury. Orchitis sometimes develops as a late symptom.

Treatment.—If the foreign body is a round, smooth object and if the case is seen early, an effort may be made to force the object to pass spontaneously. If necessary, the meatus may be divided and the urethra *in front of the body* dilated. The patient is then instructed to allow the urine to accumulate in the bladder; when the viscus has become distended, sterilized liquid cosmolin is injected into the canal and the patient instructed to make a powerful effort to urinate, the preputial opening being held tightly closed. This will dilate the urethra and permit the foreign substance to be expelled. If the object is lodged just behind the meatus, an assistant should be directed to place a finger on the under surface of the urethra, directly behind the body, to prevent it from being pushed

further downward when an attempt is made to dislodge it. A pair of urethral forceps are then inserted into the canal, and the object firmly grasped and withdrawn. When the body is lodged in the deep portion of the penile urethra, some mechanical contrivance, such as that of Thompson, Collins, Dittel, d'Etiolles, Mathieu, or Nélaton, designed for the purpose, must be employed. Pieces of wood or bits of broken catheter can frequently be grasped and withdrawn by means of any of the urethral forceps devised for the purpose. If they are firmly wedged in the posterior urethra, or are partially within the urethra and project back into the bladder, a perineal urethrotomy must be performed. Pins, needles, and hairpins introduced with the sharp end pointing toward the meatus can be removed without operation only with extreme difficulty. A very ingenious and simple device is described by Poulet: The head of the pin firmly fixed with the thumb of the left hand; the penis is next bent at the part of the urethra that corresponds to the point of the instrument, which, in consequence, protrudes through the walls of the canal, and is withdrawn until the head comes in contact with the floor of the urethra. The shaft of the needle is now drawn down toward the root of the penis, and then, by pushing upward, the head of the pin emerges from the meatus and is withdrawn. If the object is a hair-pin, both points of the pin are made to protrude through the urethral wall; one is cut off with pliers and the remaining one is pulled downward, then pushed upward, until the round end of the hair-pin presents itself at the urethral orifice. The small punctures thus made in the urethra heal readily.

A stone impacted behind the meatus or in the fossa navicularis is readily removed with an ordinary pair of narrow-bladed dissecting forceps. When embedded in the spongy portion of the urethra, it may be removed with Bonnet's articulated scoop or Hunter's forceps. An ingenious device for the removal of stone is that suggested by Marini; this consists of a wire loop, bent about half an inch from the end, into the shape of the coudé catheter. This is inserted behind the stone; the walls of the urethra contract down on the calculus and hold it firmly in the grasp of the loop and bend of the instrument, by which means it can easily be removed. When the stone is lodged in the deep urethra, it is wisest to attempt to push it back into the bladder and then perform litholapaxy. If this is impossible, it should be removed by urethrotomy. The utmost care and gentleness must be exercised in manipulating urethral instruments in the removal of foreign bodies; if the object is not readily grasped and easily removed, it is far safer to perform a urethrotomy early and remove the object, than to inflict traumatism on the delicate urethral structures by rough and often unavailing efforts to dislodge it. When the stone cannot be extracted through the meatus, two methods of treatment are to be considered: that of propulsion, working the stone backward into the bladder, and crushing it by means of a lithotrite; when this is inexpedient or impossible, the urethra should be incised and the stone removed.

URETHRAL CALCULI.

Urethral concretions are composed entirely of phosphate of lime, differing in this particular from stones that come from the kidney or bladder, which consist of urates, oxalates, triple phosphates, or cystin. They may be single or multiple in number, and vary greatly in size.

In long-standing cases the stone may either become partially embedded and fixed in the wall of the urethra, or a diverticulum may form that may contain an incredible number of stones. In these cases, especially if associated with tight stricture, urethral fistulas are of common occurrence. Peri-urethral abscess and rupture of the urethra, with infiltration of urine, are late complications. Stricture is present in the majority of cases.

The **symptoms** of a calculus formed *in situ* simulate those of a stricture of large caliber. In cases of impassable stricture associated with stone a diagnosis can be made only as the result of palpation or from an *x*-ray photograph. When the stone is embedded in the urethra or in a false passage, there is but little obstruction to urination. When lodged in the penile urethra, they can readily be detected on palpation. If the stone is small, and is situated in the portion of the urethra covered by the scrotal attachment, palpation as a means of diagnosis cannot be relied upon. When lodged in the posterior portion of the canal, they can usually be felt by digital examination of the rectum. In all doubtful cases an *x*-ray photograph should be taken. When a small stone only partially obstructs the urethra and cannot be felt on palpation, a stone-searcher should be inserted into the urethra. When the instrument comes in contact with the stone, a gritty sensation will usually be imparted to the examining hand. An endoscopic examination will generally reveal the presence of small stones embedded in the urethra.

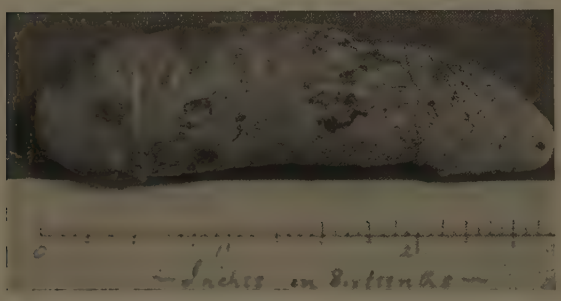

FIG. 289.—URETHRAL CALCULUS (J. M. Cotterill, Esq., of Edinburgh).

Removed from the prostatic and membranous urethra of a man of forty, who had undergone lithotrity some six years previously.

Treatment.—The method of extracting a concretion that has originated in the urethra differs from that pursued when the canal is occluded by fragments of vesical or renal calculi. The various instruments devised for extracting ordinary foreign bodies cannot be used in such cases. As the calculus is either held fast behind a tight constriction or is partly encysted, the concretion can safely be removed only by performing an external urethrotomy.

The urethra may be incised externally on the floor, in any portion of

its course, with perfect safety, and with far better results than can possibly be attained by attempts at extracting foreign bodies with hooks, scoops, or forceps.

When a stone is lodged behind a contracted meatus or is embedded in the fossa navicularis, it can readily be reached by performing meatotomy, or by making an incision on the floor of the urethra of sufficient length to render extraction easy. If the stone is not too large, it may be grasped by a pair of urethral forceps, through a small incision on the floor of the canal, and then crushed, and the fragments removed with a small scoop or by irrigation, the incision being closed by a few fine silk sutures. When the body is lodged in the penile urethra behind a tight structure, an external urethrotomy should be performed. The stone can easily be detected on palpation as a hard mass on the under surface of the urethra. It should be grasped between the index-finger and thumb of the left hand. An incision should be made over the mass, cutting downward, and the urethra incised sufficiently to allow ready extraction of the stone. The stricture should then be divided and the urethra fully dilated, a soft-rubber catheter being inserted through the canal into the bladder, and allowed to remain until the urethral wound heals. The incision in the urethra is closed by means of interrupted fine catgut sutures and the edges of the skin wound are approximated by silk sutures.

When a stone is lodged in that portion of the urethra that is covered by the scrotal attachment, a perineal urethrotomy should be performed, and an effort made to extract the stone posteriorly through the perineal wound; if this fails, the scrotum should be divided along the raphé, in the median line, the testicles being separated and held aside by an assistant while the surgeon dissects down upon the urethra and removes the stone. The stricture is divided and perineal drainage established. The wounds in the urethra and scrotum are closed in the usual manner.

When a stone is embedded in the membranous or prostatic urethra, a perineal urethrotomy should be performed. A diverticulum should be opened, the impacted stones removed, and the sac excised. A stone lodged in the patulous opening of a urethral sinus is usually small, and may occasionally be loosened by means of the jointed curet of Leroy d'Etoilles, and then extracted with urethral forceps. Should this fail, it can generally be readily pushed back into the bladder and then crushed. If it is found impossible to loosen the calculus from its attachment, an external urethrotomy should be performed and the concretion removed.

RETENTION OF URINE.

Retention from shock, spasm, or inflammation of the urethra or neck of the bladder is very common. An overdistended bladder is often the result of mechanic or pathologic obstruction in the prepuce, penis, urethra, or bladder. It may develop as the result of pressure from deep-seated abscess, effusion of blood, extravasation of urine into the perineum, pelvic tumors, exostosis of the pelvic bones, fecal accumulations, foreign

bodies, or the impaction of undigested food; it may also arise in hysteria, peritonitis, and paravesical inflammation.

"*Paralytic retention*" is often associated with cerebral and spinal diseases or injuries. A temporary paralysis occasionally develops in malaria, diphtheria, scarlatina, or typhoid. A partial retention occurs in urethral strictures of small caliber, hypertrophy or atrophy of the prostate gland, general arteriosclerosis, or a fibrosclerosis of the neck of the bladder.

A *hysteric form* is occasionally encountered in nervous, impressionable men. Contusions or laceration of the abdomen, bladder, or urethra are often accompanied by retention.

The condition may be purely *reflex*, as when it follows operative procedures within the pelvis, on the rectum, or along the genito-urinary tract. It frequently complicates strangulated hernia and suppurative appendicitis. It may develop gradually or suddenly. In the former case the retention is only partial at first, the retained fluid being known as "residual urine."

Symptoms of Acute Retention.—The symptoms of complete retention of sudden onset are characteristic, *provided there does not coexist a paralysis of the muscular structure of the bladder with a loss of sensation.* When the overdistention is caused by priapism, injury, spasm, inflammation, or sudden obstruction of the urethra or neck of the bladder, stricture, hypertrophy of the prostate, calculus, or vesical tumor, pain is usually early and marked. There is an urgent and constant desire to micturate, but not a drop of urine can be voided. Occasionally, however, as the result of violent straining, a few drops, a small jet, or a little gush may be extruded, but the urine is never passed in a full stream or in any considerable quantity. If the overdistention of the bladder is not relieved, the patient becomes restless, the body is inclined well forward in the effort to relieve the pressure of the abdominal walls on the overdistended viscus, and the face assumes an agonized expression. Thirst, rigors, flushes of heat, and a sense of weight and discomfort in the pelvic region are usually present. Fever occurs late. A pear-shaped circumscribed tumor can be seen in the median line of the hypogastrium; this is tender on pressure and *not affected by change of position.* If the retention remains unrelieved, the tumor increases very slowly in size. The distended bladder may easily be felt on rectal palpation. When the distention causes pressure on the rectum, difficult defecation and pain in the lower bowel are experienced.

A most important early symptom is *constant dribbling of urine.* This is observed especially in paralysis of the bladder with complete retention, and is known as the "incontinence of retention." In all cases of dribbling of urine a catheter should be inserted into the bladder; this has frequently disclosed the fact that patients believed to be suffering from incontinence are in reality suffering from retention.

If the condition remains unrelieved, a fatal termination will usually ensue in from four to six days, being preceded by restlessness, high fever, thirst, headache, and a quick, soft, compressible pulse. The breath and perspiration give off a urinous odor. Finally the skin becomes bathed

in a cold, clammy sweat, hiccup, twitching of the tendons, nausea, and vomiting occur. Delirium and coma finally set in.

Symptoms of Chronic Retention.—In the early stage of paralysis of the bladder, accompanied by loss of sensation, occurring before cystitis develops, an enormous accumulation of urine may occur without producing marked distress. The first symptom is a dribbling of urine, which may be mistaken for incontinence. When retention develops as the result of a prolonged fever, it is partial at first, gradually becoming complete. At the onset there may be an increased desire to micturate, a symptom that may escape notice if delirium occurs. The urine slowly accumulates in and distends the bladder, until the intravesical tension becomes so great as to overcome the contraction of the sphincter muscle, which relaxes, permitting a dribbling to take place.

A gradually increasing amount of residual urine, due to obstruction, such as stricture, contracture of the vesical neck, hypertrophy of the prostate, or intravesical or extravesical tumors, gives rise to little discomfort until a posterior urethritis or urethrocystitis develops. In partial retention due to accumulation of residual urine before infection of the bladder has occurred the only symptom is an increasing desire to micturate.

In atony of the bladder associated with fibrosclerosis of the vesical neck or atrophy or hypertrophy of the prostate polyuria may develop, the kidneys continually pouring fluid into a partially paralyzed bladder with an obstructed outlet; in consequence, a large quantity of urine accumulates in the viscus, and the desire to urinate becomes abnormally frequent. If the obstruction is not relieved, more distressing symptoms gradually develop, such as a difficulty in starting the flow. The caliber of the stream is diminished, the parabolic curve lost, and a slight dribbling follows the act of urination.

When infection of the bladder occurs, pain is characteristic and marked, except in those cases associated with complete paralysis of the organ and loss of sensation. The pain may involve the perineum, back, or thighs, or run along the course of the urethra, becoming aggravated during urination, or it may be felt back of the glans or over the pubes. Hematuria is a late symptom. As the result of straining, hemorrhoids, prolapse of the rectum, or hernia may develop. In chronic retention in which only partial suppression occurs the condition may gradually or suddenly become complete with the development of acute symptoms.

Treatment.—A bladder that is very much overdistended should never be completely emptied at once. Whenever expedient, about half the quantity of the retained urine should be evacuated at one time; half the remaining quantity being withdrawn in the course of three hours, and the remainder some hours afterward.

In *congenital retention* occasioned by an imperforate prepuce an incision may be made on the dorsal surface of the prepuce or circumcision performed. An occluded meatus demands the performance of meatotomy. If the retention is not caused by occlusion of the prepuce or the meatus, the inference is that it is due to a cyst in the sinus pocularis, a condition

that is easily corrected by passing a small, slightly curved silver probe very gently through the urethra to the bladder. The cyst walls are exceedingly thin and delicate and are easily ruptured, when the urine is voided without difficulty. Great gentleness must be observed in passing the probe, as in young subjects the canal is extremely likely to be severed at the bulbomembranous junction by rough manipulation.

Overdistention of the bladder due to *shock, hysteria, neurasthenia, constipation,* or *prolonged voluntary retention* may frequently be overcome by administering a rectal enema consisting of one ounce each of magnesium sulphate and glycerin, six ounces of milk of asafetida, and a pint of soapsuds. The patient is then given a hot bath, and directed to make an effort to empty the bowel while in the water. Usually the urine is expelled as the enema is passed. Should the clyster fail, aseptic catheterism must be resorted to.

In retention caused by the *spasm or inflammation associated with an acute posterior urethritis,* when there is but little distention of the bladder, and the symptoms, therefore, are not urgent, a hot bath followed by a hot drink and a hypodermic of morphin, $\frac{1}{4}$ grain, should be administered. If this fails, catheterism must be resorted to. After the urine has been withdrawn, free perspiration should be induced and an opiate administered. A brisk purgative should then be given and the patient put at rest.

A *mechanical obstruction* or growth within the urethra must be removed (see p. 510).

When the overdistention of the bladder is caused by *malignant disease of the penis* involving the urethra, it may become necessary to institute either perineal or suprapubic drainage. When the cause of the obstruction is situated outside of the urethra, as when there is an accumulation of blood, pus, or urine in the perineum, the *urethra not being implicated,* the introduction of the catheter causes great pain and gives only temporary relief. In such cases an incision should be made and free drainage instituted. If the swelling is in the perineum and *the urethra is not involved,* a perineal section is all that is required; if the urethra is ruptured, *a perineal urethrotomy should be performed as soon as possible.*

When the inability to evacuate the contents of the bladder is caused by a spasmodic urethral stricture of large caliber, a metal catheter should be passed gently along the urethral canal until the obstruction is encountered; steady but firm pressure should now be made on the face of the stricture, which will cause it to yield suddenly, permitting the instrument to glide onward and enter the bladder. In emergency cases, when a patient is seen for the first time, it is often impossible to pass a filiform bougie or a small rubber or silk catheter. Before resorting to aspiration of the bladder or operative measures it is well first either to inject into the urethra 1 dram of a 2 per cent. cocain solution, or to induce the first stage of ether anesthesia, when it will not infrequently be found that a full-sized metal catheter can readily be inserted.

When the stricture will permit the passage of a filiform bougie and a

Gouley tunneled catheter, the symptoms are speedily relieved. After the urine has been withdrawn the metal catheter should be removed, and a filiform bougie inserted and left in place, when it will be found that the urine will pass alongside of the instrument, thus preventing retention.

When the caliber of the stricture is so small that only a filiform bougie can be passed, which fails to relieve the urgent symptoms, suprapubic puncture or aspiration of the bladder should be performed, and the patient given a hot bath, a hot drink, and an opiate; a flaxseed poultice, large enough to cover the lower abdomen, should be applied. When the bladder again becomes distended, another effort should be made either to pass the tunneled catheter over the filiform bougie or to slip a small metal or silk catheter alongside of it, in order to reach the bladder. Should these expedients fail, an external perineal urethrotomy should be performed, using the filiform bougie as a guide (see p. 570).

When the stricture is impassable and the symptoms are urgent, the bladder may be aspirated or punctured above the pubes, and the patient relaxed in the manner previously described, after which another attempt may be made to insert an instrument; if this also fails, a perineal urethrotomy without a guide should be performed as soon as possible (p. 572). If the retention has existed for a number of hours before the patient is seen, and if numerous unsuccessful attempts have been made to dilate the stricture, operation should be undertaken without delay.

This consists in making a suprapubic puncture one inch above the pubes, in the median line, with the largest sized needle in the aspirating outfit. The needle is held between the index-finger and thumb of the right hand, and so guarded that when the sudden puncture is made, it will not penetrate too deeply. After entering the viscus the stilet is withdrawn and the urine permitted to flow through the cannula until the bladder is emptied. Before withdrawing the tube irrigate the bladder with a hot sterile boric-acid solution. The needle puncture should be covered with a bit of sterilized cotton, fixed in place with collodion.

A common cause of retention is *prostatic hypertrophy*. The treatment in these cases consists in the employment of a catheter of such a shape as to allow it to be successfully insinuated along the tortuous course pursued by the prostatic urethra. Beyond suprapubic puncture or aspiration, operation for the relief of this condition is seldom necessary.

In order to relieve retention due to prostatic hypertrophy the instruments necessary are the soft-rubber, rat-tailed, olive-pointed, coudé, bicoudé, Guyon's flexible prostatic, the ordinary metal catheters, and the overcurved silver catheter devised by Brodie. These should be from 12 to 15 inches in length. Attempts to catheterize such cases often fail because the instrument employed was too short to reach the bladder. The caliber of the instrument best suited to the majority of cases is about No. 15 or 18 French. Nothing but harm can follow the attempt to force too large an instrument through the canal in cases in which there is not only urethral obstruction, but spasm and inflammation of the posterior urethra and neck of the bladder as well.

In cases of retention associated with a *fibroid thickening of the prostatic isthmus*, with contraction of the vesical neck, antiphlogistic treatment should be instituted. As a rule, in these cases there is little or no difficulty in inserting either a soft-rubber or a flexible silk olive-pointed catheter. Should these fail to pass, an ordinary metal instrument should be employed. When the urethra is deflected to one side, the soft, pliable, rat-tailed catheter is the instrument of choice. When, as a result of hypertrophy of the isthmus and the development of a pathologic middle lobe, the urethra forms an angle, the angled coudé catheter is the one to be employed. When there is an inordinate enlargement, with lengthening of the urethra and elevations of the vesical outlet, a bicoudé catheter should be relied upon to relieve the condition; if this fails, the overcurved metal catheter of Brodie will frequently succeed. When prolonged efforts at catheterism have proved unsuccessful and the bladder is markedly distended, either suprapubic puncture or aspiration should be performed; relaxation is then secured by administering an opiate and a hot bath, and as soon as the urine has reaccumulated, another effort may be made to reach the bladder with a catheter. If the first or second puncture fails to relieve the condition, suprapubic drainage should be established without further delay. In cases of overdistention in which repeated attempts at catheterism have failed, and severe traumatism has been inflicted upon the urethra and prostate, as evidenced by urethral hemorrhage, the bladder containing blood-clots as well as urine, a suprapubic opening should be made immediately.

In elderly subjects, when the retention is due to *an impassable stricture, as well as to hypertrophy of the prostate gland*, suprapubic drainage should be promptly established, the stricture being dealt with at a second operation, after the patient is convalescent. When the prostatic urethra is contracted by the encroachment of the growth, it is seldom possible to relieve a sudden retention by catheterism. If the patient's age and condition warrant it, either a perineal or a suprapubic prostatectomy may be performed; in the aged, feeble, and uremic, permanent suprapubic drainage should be established.

Retention due to *vesical calculi or tumors* may be relieved by the introduction of a soft-rubber catheter.

A *coagulation of blood* may take place in the bladder, obstructing the vesical outlet and causing retention of urine, a condition that is not free from danger and is often difficult to relieve. The source of the hemorrhage may be the kidney, bladder, posterior urethra, or prostate gland. In such cases the employment of an ordinary catheter is usually unsuccessful, for the eye of the instrument becomes occluded with clotted blood. An attempt to dislodge the obstruction may be made by injecting a hot 1 per cent. solution of phenol through a catheter by means of a hand syringe. When the hemorrhage has been profuse and a clot of large size is present, the overcurved silver catheter of Brodie, or the blood catheter devised by Gross, should be employed. As soon as the urine is evacuated an effort should be made to get rid of the clot by breaking it up by means of the instrument in the bladder, and washing it out by irrigating with a

hemostatic solution. If all attempts at catheterism fail, a small-sized lithotrite should be introduced and an attempt made to crush and churn the clots in the bladder, emptying the contents from time to time by means of the evacuating catheter of the Bigelow apparatus, washing out the viscus with hot adrenalin solution. If this method is successful and the bladder is emptied, a full-sized soft-rubber catheter should be inserted and continuous drainage instituted. The patient should be kept at rest, and a full dose of opium and fluidextract of ergot administered. When the bladder is enormously distended and the symptoms are urgent, all attempts at catheterization or at breaking up the clot having failed, suprapubic cystotomy should be performed.

The treatment of chronic retention associated with the presence of residual urine is fully described in the sections devoted to the consideration of the various affections that give rise to this condition.

TUBERCULOSIS OF THE URETHRA.

Tuberculosis of the urethra may be secondary or primary in nature. A primary involvement is much more common than is generally believed, this affection being usually mistaken for a chronic urethritis; the initial lesion of syphilis; a periurethral infiltration; or an abscess, fistula, or stricture the result of an antecedent gonorrhea. The male urethra is more frequently attacked by tuberculous disease than that of the female.

The **symptoms** of a **primary infection** are vague. The histories of the few cases of primary tuberculosis of the urethra that came under my care show that previous chronic gonorrheal infection had existed, accompanied by epididymitis, orchitis, deferentitis, vesiculitis, or prostatitis. The suspicion of a tuberculous urethritis is confirmed by the development, later, of a similar infection in some organ connected anatomically with the urethral tract. When the deep urethra is affected, the act of micturition is frequently accompanied by a disagreeable burning sensation. Occasionally slight pain in the region of the neck of the bladder, together with intermittent attacks of dysuria, is complained of. This is sometimes relieved by the passage of a small mucopurulent mass. In four cases seen by me the only symptom that occurred during the first six months was an unexplainable tinging of the ejaculated semen with blood. There was a pronounced hereditary tendency to tuberculosis. Endoscopic examination revealed the presence of a superficial ulceration near the mouths of the ejaculatory ducts in two cases, the urethra being normal in the others. In all, the tuberculous infection had a tendency to descend. In no instance did the ureter or kidney become implicated. A microscopic examination of the seminal fluid showed the presence of tubercle bacilli in only two cases.

A **secondary tuberculosis of the urethra** is characterized by an obstinate chronic urethritis that is uninfluenced by treatment, and is aggravated by the silver salts. There is increased frequency of urination, and pain occurs along the course of the urethra and at the penoscrotal junction. If the ulcerative process involves the prostatic urethra, tenesmus adds

to the discomfort. Hematuria is not a frequent symptom, and is generally intermittent and transitory. When the deep urethra is involved, there may be a terminal hematuria.

Diagnosis.—A positive diagnosis of primary tuberculosis of the urethra in the early stage is reached only with difficulty. The unexplainable ejaculation of bloody semen without the presence of other symptoms is always to be regarded with suspicion. Time frequently confirms the diagnosis, the disease extending to some neighboring structure or organ.

In secondary invasion of the urethra the condition is recognized earlier, as the urethral symptoms are associated with those manifested by the organ in which the infection originated. A definite conclusion may usually be reached by a careful study of the history. An endoscopic examination of the urethra, together with a chemic, microscopic, and bacteriologic investigation of the urine and of the secretions and discharge from the genito-urinary tract, should also be made. Even in the advanced stages of the disease tubercle bacilli may be absent.

In primary tuberculosis of the urethra the **prognosis** is favorable provided the patient receives the proper treatment. When the involvement of the urethra is secondary, the prognosis is grave.

The **treatment** is both local and constitutional. Hygienic surroundings, proper diet, and suitable climate play just as important a part in the treatment of urethral tuberculosis as in that affecting any of the other structures of the body. Alcoholic beverages and sexual indulgence should be prohibited. Increasing doses of creasote, continued over long periods of time, and given in conjunction with iron and forced feeding, are serviceable in any form of genito-urinary tuberculosis.

A primary single lesion of the urethra may be treated locally by passing an endoscopic tube down to the seat of infection and endeavoring to destroy the lesion by means of the curet, after which the wound is insufflated with iodoform and the patient kept at rest. If the ulcer is not extensive and so situated that its removal is feasible, the implicated portion of the canal may be resected and the ends of the resected urethra approximated by interrupted catgut sutures, continuous drainage being established by means of a catheter until union takes place.

In those cases of suspected primary invasion accompanied by an intractable discharge which is not benefited by any method of treatment, irrigation with a hot solution of mercury bichlorid 1 : 20,000 will sometimes give most gratifying results. When the lesions are situated in the anterior urethra, the canal should be gently irrigated with a sterilized boric-acid solution, and the following emulsion applied to the ulcerated surface by means of an applicator passed through an endoscopic tube:

Iodoform	gr. cccl x
Pulv. tragacanth	gr. xj
Spt. vini rect	♏lxxx
Aquæ dest	℥viij

When the lesions are confined to the posterior urethra, the bladder being healthy, it is best to disturb the canal as little as possible. In such cases

I seek to flush the canal by instructing the patient to urinate, after which about thirty minims of the iodoform emulsion are instilled gently into the deep urethra by means of a sterilized Keyes-Ultzmann syringe. This treatment should be administered every third day, and continued over a long period of time.

A tuberculous stricture associated with urethral fistula should be treated by performing a combined internal and external perineal urethrotomy. When the urethra and body of the penis become extensively involved in the tuberculous process, amputation of the organ may be demanded.

TUMORS OF THE URETHRA.

Tumors of the urethra are of rare occurrence; when they occur, they are similar in nature to, and require the same treatment as, neoplasms occurring in other portions of the body.

Papilloma of the urethra occurs in several different forms, being seen most often as caruncle, multiple papillary growths, polypi, and papillomatous vegetations the result of chronic specific urethritis.

Primary **sarcoma** of the urethra is practically unknown. **Secondary carcinoma** of the urethra may follow as the result of a cancerous process in the rectum, bladder, prostate, or penis.

A **primary carcinoma** of the urethra, while very rare, has occasionally been observed. If the malignant character of the disease is recognized early and the carcinoma is so situated as to make urethrectomy possible, this operation should be performed without delay; when, however, this is impossible, complete extirpation of the penis and urethra should be performed.

INFLAMMATION OF THE MALE URETHRA (URETHRITIS).

There are two forms of urethritis—non-specific and specific. The inflammatory process may be acute, subacute, or chronic; it may be limited either to the anterior or to the posterior portion of the canal, or it may involve the entire urethra; in the latter case it is known as an *anteroposterior urethritis*.

Any morbid condition that has a tendency to keep the mucous membrane of the urethra continually congested predisposes it to attacks of inflammation. The urethra is the habitat of a large variety of organisms, many of which are non-pathogenic and innocuous in the absence of pathologic conditions. Micro-organisms may be introduced into the urethra from without, as in the descent of infected urine from the kidneys, or they may come from a focus of chronic infection outside of the urethra. An inflammation developing under such circumstances is known as a "*concomitant urethritis*."

The **non-specific** variety of urethritis is rare as compared with the specific form, known as gonorrhea. In the non-specific variety the disease generally runs a mild course and is amenable to treatment, tending to subside in from eight to ten days.

A form frequently described as "*irritative urethritis*" may be provoked by the ingestion of certain foods and drugs. Diabetes, the rheumatic or gouty diathesis, chronic eczema, herpes involving the penis, irritating injections, sexual excesses, prolonged sexual excitement, and chronic constipation may all be mentioned among the exciting causes. Traumatism, foreign bodies or calculi in the urethra, neoplasms, stricture, invasion of the canal by animal parasites, may be mentioned among the etiologic factors. Finally, the inflammation may be secondary to a morbid process outside the urethra. Abnormal conditions of the urine and a prolonged and too vigorous treatment of chronic localized urethritis may also give rise to this form of infection. In rare instances a non-specific urethritis may prove rebellious to treatment, and become converted into a chronic condition that may be attended by severe complications.

A **specific urethritis** that is also infectious may be due to a syphilitic lesion, chancroid, tuberculosis, typhoid, pneumonia, diphtheria, and, finally, infection from pyogenic organisms or gonococci. A specific urethritis that is non-gonorrheal in character may result from contact with a uterine or vaginal secretion that contains pyogenic organisms, or from coitus during or at about the menstrual period. This form of inflammation may also follow the introduction of infected instruments, alcoholic excesses, and repeated attacks of gonorrhea.

The **symptoms** of specific urethritis due to the ordinary pus-producing micro-organisms are similar to those accompanying an attack of gonorrhea; they are usually, however, of a milder type. The affection, moreover, tends to subside in the course of two weeks, provided the treatment is not conducted in too heroic a manner. Occasionally this variety of urethritis may be attended by a profuse discharge and by the development of severe complications, the local condition finally becoming chronic; the discharge is catarrhal in nature, and may persist for weeks, months, or years, the patient eventually becoming a profound sexual neurasthenic.

Gonorrhea.

This variety of specific urethritis is an infectious suppurative process, inflammatory in character, whose causative agent is a specific micro-organism known as the gonococcus, which is never found in the normal urethra. It is the most common form of venereal infection, and is acquired as the result of either mediate or immediate infection.

Gonorrhea is a virulent inflammation, attacking not only the entire urethral mucous membrane, but eventually invading also the submucous tissues, and being accompanied by an active cell proliferation. After one attack the mucous membrane is never completely restored to its normal condition, for the desquamating patches of cylindric epithelium are replaced by the squamous variety. The time that elapses between inoculation and the development of symptoms varies markedly in different individuals.

The fossa navicularis is the first portion of the urethra to participate actively in the inflammatory reaction, which gradually extends, by

continuity of tissue, until a large portion or even the entire mucous surface is invaded. When the organisms have gained access to the canal, they rapidly proliferate and eliminate toxins that are in themselves extremely irritating to the mucous membrane.

In long-standing cases of gonorrhea the mucous membrane of the urethra seems to become less susceptible to the toxins eliminated by the gonococci, which apparently lose their irritating effect; thus it is seen that in oft-repeated relapsing cases the resulting inflammatory symptoms are less severe than those that attend primary infection. The glands of Littré are extremely likely to become implicated in the gonorrheal process.

Following occlusion of the ducts of these glands cysts are formed; these contain colloid substances that may undergo suppuration, giving rise to "follicular abscesses." When the ducts remain patulous and an acute inflammation of the glandular structure occurs, a condition known as "glandular urethritis" develops.

A chronic gonorrheal process of the glandular tissue may remain latent for an indefinite time. In this condition the glands are converted into hard, nodular masses that can readily be felt along the under surface of the urethra on palpation.

As the result of specific inflammation the lacunæ of Morgagni may become atrophied and disappear; occasionally they become filled with the débris of the exfoliated epithelium, forming small cysts that, in turn, may suppurate, giving rise to a peri-urethral abscess or to a urethral fistula.

When the disease becomes chronic, it shows a decided tendency to become localized to one or more portions of the urethra, having a preference for the region of the fossa navicularis and the bulbous and prostatic portions of the canal. Congested patches, glandular patches, erosions, ulcerations, "nacreous patches," papillomatous vegetations, and edematous folds are among the lesions that attack the mucous membrane in chronic gonorrhea. The membranous urethra is but seldom implicated; when it is involved, the process usually follows a periurethral cell infiltration that has extended from the bulbous portion of the canal. Besides the inflammatory condition of the prostatic urethra, small follicular abscesses are likely to form, which rupture and discharge pus into the urethra, cicatrization being followed by the formation of small indurated masses. The verumontanum frequently becomes thickened and indurated, and the mouths of the ejaculatory ducts become patulous and rigid. A portion of or the entire organ is frequently the seat of a subacute or a chronic inflammation.

Acute Anterior Gonorrheal Urethritis.—Occasionally the acute symptoms appear suddenly, but in the majority of cases there is a prodromal stage, which lasts, on the average, from three to four days. In mild attacks the only symptom is often a slight irritation of the terminal portion of the urethra. A tickling or itching sensation serves to fix the patient's attention on the organ. The lips of the meatus are slightly swollen and congested, and bathed in a glairy, mucous discharge that causes the lips to adhere between the acts of urination. When the onset

is more acute, the lips of the meatus are swollen, pouting, and reddened, and the region of the urinary orifice is congested. The mucous membrane of the urethra presents a deep-red, glazed appearance, and is covered with mucus. There is a sensation of burning or heat during urination, and frequent recurring erections or partial priapism constitute a distressing feature. A severe prodromal stage is usually of short duration, the discharge rapidly becoming purulent.

The acute, purulent, or florid stage is usually characterized by pain, swelling, discoloration, and the discharge of pus. Anxiety and depression are not uncommon. In nervous patients there may be malaise or slight febrile reaction.

In many instances the disease pursues a mild course, the symptoms consisting merely of a purulent discharge and a slight burning sensation. In the purulent stage a small amount of blood is frequently mixed with the discharge. In some cases the disease may be marked by the onset of very mild inflammatory symptoms that gradually subside in the course of six weeks; in others, the inflammatory symptoms may be severe, or the condition may pass into the stage of decline and be attended by complications that may prolong the process indefinitely.

The character of the *discharge* varies with the nature of the inflammatory reaction. In the beginning of the florid stage it is purulent and frequently sanguinolent. It may be but slight or extremely profuse, being most free in the morning and diminishing as night approaches. It may be thick or watery, and is generally of a light cream or dirty, greenish-yellow color. At this stage the urine will be cloudy and contain pus-cells loaded with gonococci, the epithelium and mucus having almost entirely disappeared.

There may be increased frequency of urination, a change in the caliber of the stream, ardor urinæ, painful erections, urethral hemorrhage, or chordee. Retention is a rare symptom. The swelling of the mucous membrane so narrows the lumen of the canal as to interfere with dilatation, and the urinary stream may be forked, twisted, or diminished in caliber.

Pain varies in intensity in different cases. It may consist merely of a slight irritation or of a severe burning or even agonizing sensation. Hemorrhage is not common. Unusual exertion, prolonged erections, ungratified sexual excitement, or coitus may, however, cause profuse bleeding. Chordee may be temporary or permanent; it usually occurs during the night, but may appear during the day. The curvature is usually directed downward, but rarely it is deflected upward or laterally. Attempts at forcibly straightening the penis by the method known as "breaking the cord" have in some instances been followed by alarming hemorrhage, and in others by the formation of stricture.

When the anterior urethra alone is affected and the patient is directed to pass a portion of the urine into a glass receptacle and then to pass the remaining quantity into another vessel, it will be observed that the first urine will be cloudy and the second clear.

Acute Posterior Urethritis.—In at least 95 per cent. of cases of gonorrhea the inflammation involves the posterior urethra. The onset

of the attack may be so mild as to pass unnoticed, or it may be sudden, violent, and severe. In the large majority of cases the extension of the inflammation to the deep urethra is not accompanied by any characteristic symptoms. The desire to micturate is generally slightly increased, and a temporary cessation of the urethral discharge occurs. In such cases the diagnosis is made by the two-glass urinary test or by lavage of the anterior urethra, followed by the passage of the urine into two receptacles, the first urine passed being clear and the second cloudy. When the onset is severe, spasm and pain at the neck of the bladder and in the perineum occur at the termination of urination, these symptoms being soon followed by a frequent desire to urinate and the expulsion of but a few drops of urine. Tenesmus of varying degree develops and the pain may become excruciating. When it is severe, albumin appears in the urine. Hematuria occurs only in the terminal stage, when bloody urine will be passed.

In cases in which the posterior urethra is gradually invaded the discharge is, as a rule, but slightly influenced. When the onset is sharp and sudden, the discharge may become more profuse or cease completely, only to reappear when the acute symptoms subside, so that in these cases the sudden reappearance of the urethral discharge is always a favorable symptom, indicating that the active posterior inflammation is abating. Recurring erections and nocturnal emissions are often troublesome. It is remarkable that, even in the severest cases, constitutional symptoms are usually absent. If fever is present, this generally indicates that a suppurative process is developing. In suspicious cases the blood should be examined and a blood count made. Complete retention of urine is not unusual in severe cases, but a condition known as "relative incontinence" is far more common. In this the compressor urethræ muscles are weakened and control of the bladder is lost, so that at the sound of running water, or when a sudden desire to urinate is not immediately gratified, a slight leakage of urine occurs.

In mild cases the attack usually subsides in the course of two weeks, leaving a subacute anteroposterior urethritis. In severe cases the symptoms gradually abate, and those of anterior urethritis, which were held in abeyance, reappear in the form of an acute exacerbation. The urethral discharge now becomes profuse. Occasionally a violent posterior urethritis terminates in unexpected convalescence and prompt recovery. More commonly a chronic localized lesion develops in the prostatic urethra or a subacute anteroposterior urethritis is left behind. If the two-glass urinary test is employed in acute posterior urethritis, both urines will be found to be cloudy. Gonococci are readily discernible in the discharge from the deep urethra.

Infection of the posterior urethra may be followed by the development of grave complications, such as inflammation of the various adjacent structures, gonorrheal arthritis, pyemia, peritonitis, and secondary involvement of distant organs.

Treatment of Gonorrhea.—In treating gonorrhea, the physician should bear in mind that he is dealing with a virulent inflammation, due to a specific infection.

Abortive Treatment.—An attempt to abort the disease should be made only in the *prodromal stage*, when the symptoms consist merely of a tickling sensation at the meatus and a slight discharge of glairy mucus. The urine is clear, but when agitated, small shreds of epithelium will be discovered floating about. The microscope will reveal the presence of epithelium and possibly of a few leukocytes. The gonococci will be found free in the serum or adherent to the epithelial cells. In the presence of such a condition abortive treatment is justifiable.

In the first stage of a gonococcic invasion the judicious employment of germicides, such as the various preparations of the silver salts, potassium permanganate, or mercury bichlorid, may be followed by gratifying results. I have had excellent results from irrigations, practised twice daily for seven or eight days, of a hot solution of either potassium permanganate or mercury bichlorid 1 : 20,000. The method advocated by White and Martin, and which I have found very serviceable, is as follows: A solution of protargol is made by dissolving five grains of protargol in an ounce of distilled water. After urination four drops of a 4 per cent. solution of eucain are injected into the urethra, followed by one or two drams of the solution of protargol, which should be retained for three minutes. The injections are repeated at intervals of two hours. Whenever the ounce bottle containing the solution is half emptied, it should be refilled with water, until, at the end of the third day, the strength of the solution has diminished to 1 : 3200. If the treatment is successful, recovery may be expected in about seven days. If the discharge persists, an antiseptic and astringent injection will be required to complete the cure. The patient should be placed at rest, and a sedative, soothing lotion should be kept constantly applied. A light bland diet and the usual balsamic remedies should be prescribed. If the symptoms become hyperacute, the treatment should be discontinued at once.

General Treatment.—The penis should always be examined in order to ascertain the character and amount of discharge; to determine to what extent the inflammatory process has involved the lips of the meatus or the glans penis, and whether any deformity or complication exists that will tend to modify the local treatment or limit the use of urethral instruments.

During the acute stage the penis should be immersed in a cup of hot water for ten minutes thrice daily. The dressings should be absorbent and should be changed frequently. The meatus should be smeared with vaselin. The patient should be warned of the danger of infection, and cautioned against carrying the infection to the eye. Soiled dressings should immediately be burned. The diet should be bland, simple, and unirritating. Alcoholic beverages should be forbidden, except in those addicted to their use; in these, small quantities of whisky or of still wines may be allowed. Coitus should be abstained from. A suspensory bandage should be worn, and the patient directed to rise during the night to urinate.

The bowels should be regulated, and the patient encouraged to drink freely of a slightly alkaline water.

In acute uncomplicated gonorrhea I have employed the following method with excellent results:

The usual instructions are given regarding rest, diet, hygiene, and cleanliness. Capsules containing cubebs, copaiba, sandalwood, and methylene-blue are to be given thrice daily, a half-hour after meals. The patient is instructed to make injections of a 10 per cent. solution of argyrol at least thrice daily, and more frequently if possible, using a hand syringe. The fluid should be retained for five minutes during the day and for fifteen minutes at bedtime. If it gives rise to pain, the solution should be allowed to pass out. In a primary attack it is well to begin with a small quantity, not over one dram at a time at first, gradually increasing the quantity to four drams. The syringe should not hold over four drams. It should be of glass, mounted with a hard-rubber cap; the distal end should be cone-shaped and fitted with a rubber cover. The piston should glide easily and smoothly in the barrel. At about the end of ten days the stage of decline generally sets in. The methylene-blue capsules and argyrol injections are now discontinued, and capsules containing cubebs, copaiba, and sandalwood are given before meals, and five-grain capsules of urotropin a half-hour after meals. An injection of 0.25 per cent. solution of protargol is now employed. If this is well tolerated, the strength should be gradually increased until a 1 per cent. solution is employed. By the end of the fourth week it will be found that the terminal stage has been reached, the only symptom being a mucoid discharge. At this stage treatment is again modified. The balsamic remedies and urotropin capsules are discontinued, and capsules of sandalwood and salol given instead. A purely astringent injection is also prescribed. The following injection, suggested by J. William White, is excellent, and may be modified to suit the individual case:

℞. Hydrarg. chlor. corr. ..... gr. ½
Zinci sulphocarbol. ..... ʒss
Acid. borici ..... ʒij
Phenol. ..... ʒ¼
Boroglycerid (25) ..... ʒij
Aquæ destil. ..... q. s. ad ʒvj.
Sig.—Inject; dilute if painful.

An injection that I have found very serviceable in the stage of decline, when the mucoid condition predominates, is the following:

℞. Zinc. sulph. ..... gr. xvj
Plumb. acetat. ..... gr. xxx
Glycer. of tannin,
Lloyd's hydrastin ..... āā ʒiv
Mucil. acaciæ ..... ʒiv
Aquæ destil. ..... q. s. ad ʒvj.
Sig.—Inject.

The injection known as "brue," the formula for which follows, is frequently efficacious:

℞. Plumbi acetat. ..... gr. xxx
Zinci sulph. ..... gr. xvj
Ext. krameria fld. ..... ʒiv
Tinct. opii ..... ʒiij
Aquæ dest. ..... ad ʒvj.

Ultzmann recommends:

℞. Zinc. sulph. ..... gr. xvj
Pulv. alum. ..... gr. vj–xij
Phenol. ..... gr. iv
Aquæ ..... ℥vj.
M. Sig.—Inject.

When all symptoms have disappeared and the patient is convalescent, the astringent injection should be gradually weakened rather than suddenly discontinued. When this method has been continued for a week and no symptoms of the disease have appeared, the patient may be regarded as cured. Alcoholic or sexual indulgence should be interdicted for at least three weeks. If a relapse occurs, the antiseptic treatment indicated for the second stage of the affection should again be employed, to be followed by antiseptic and astringent remedies when the stage of decline again sets in.

Treatment of Severe Acute Posterior Urethritis.—When the morbid process involves the posterior urethra, all local treatment is to be abandoned until the symptoms subside. In the milder forms the patient may be allowed to be up and about, but there should be as little exertion as possible. The diet should be restricted, the bowels regulated, and the patient encouraged to drink freely of an alkaline water. Capsules containing cubebs, copaiba, sandalwood, and methylene-blue should be taken before meals, and a sedative mixture after meals. In a few days the inflammatory symptoms will subside, when the usual method of treatment may be employed. When the onset is violent, with pain, hemorrhage, dysuria, and tenesmus, the patient should be placed at absolute rest and a liquid diet prescribed. Frequently repeated hot sitz-baths, and the application of a hot-water bag over the pubes and perineum, greatly relieve the pain and spasm. If these become unbearable, a hypodermic injection of morphin, $\frac{1}{4}$ grain, and atropin, $\frac{1}{100}$ grain, should be given directly into the tissues of the perineum. Retention of urine constitutes a painful complication, and demands systematic aseptic catheterization.

Chronic Anterior Urethritis.—In most instances there are no symptoms beyond the presence of a mucopurulent or a scanty mucoid discharge, usually occurring in the morning. A burning sensation along the course of the urethra is sometimes complained of, and there is frequently a slight dribbling of urine at the end of micturition. Acute symptoms, the result of either alcoholic or sexual indulgence or a too active overstimulating treatment, are likely to develop. If the urine is passed into two glasses, the first will be found cloudy and the second clear.

If the urethra is examined with the endoscope, congested and granular patches, erosions and superficial ulcerations, or "nacreous" patches will be seen; the last-named lesions usually precede the formation of stricture. The inflamed mouths of the ducts of the glands of Littré can plainly be seen on the floor and roof of the urethra, and be detected on passing a steel bougie into the canal and running the finger along the under surface of the urethra, when a number of small nodules can be

felt. Occasionally the entire anterior urethra, but more frequently only the membranous portion, becomes indurated and rigid and its elasticity impaired.

Chronic Posterior Urethritis.—The symptoms of this affection may be either very mild or very severe. Thus, beyond a turbidity of the urine, caused by the presence of gonorrheal threads, there may be no other symptom. If these cases do not receive proper treatment, they may drag along for years. Occasionally a slight mucoid discharge is seen, usually in the morning; this is readily controlled by an astringent injection. The desire to micturate may be increased, and there may also be pain. Nocturnal pollutions are common. The semen may be tinged with blood and ejaculation is frequently painful. Atonic impotence not uncommonly exists. If the disease persists, the patient frequently develops sexual neurasthenia.

When the discharge is mucopurulent, the balsamic remedies are indicated, together with the use of urinary antiseptics, such as salol and urotropin. The diet should not be too restricted. Alcoholic and sexual indulgence should be prohibited.

Superficial ulcerations or erosions are best treated by irrigations of the anterior urethra every other day with a solution of silver nitrate 1 : 10.000 or protargol 1 : 2000, after which a soft-rubber catheter should be passed into the bladder and the viscus filled with the medicament; the instrument should then be withdrawn, and the patient instructed to evacuate the contents of the bladder; in this way the entire canal is flushed. An endoscope should now be passed, and a strong stimulating lotion, such as a 2 per cent. alcoholic solution of phenol or silver nitrate 2½ grains to the ounce, should be applied by means of an applicator. The strength of the solutions may be gradually increased as the effect produced warrants. When the mucous surface is markedly congested, or in erosions or ulcerations associated with a periurethral infiltration that narrows the lumen of the canal and interferes with its normal elasticity, gradual dilatation, employed in conjunction with a stimulating ointment, will frequently effect a cure. If necessary, a meatotomy should be performed. The entire urethra is irrigated with a protargol solution, 1 : 2000, after which a steel bougie that will comfortably dilate the urethra is smeared with the ointment and inserted. It is allowed to remain for at least five minutes, unless it produces pain. If there is a follicular involvement, the under surface of the urethra should be massaged with the index-finger, making pressure on the diseased glands and forcing out any pathologic secretion they may contain and allowing the remedy to come in contact with the foci of the disease.

Among the many ointments prescribed, those in most general use are:

℞. Iodin ..... gr. vj
Kalii iodid. ..... gr. xxx
Ol. amygdal. ..... ʒj
Lanolin ..... ʒj. (*Finger's ointment.*)
M.

℞. Argent. nit. . . . . gr. xv
Lanolin. . . . . ʒiij
Ol. oliv. . . . . ʒiss.
M.

Another formula is:

℞. Ichthyol . . . . . gr. xv
Balsam. Peru . . . . . ʒiv
Resorcinol . . . . . gr. xj
Ol. ricin. . . . . ʒiv.
M.

In chronic congested patches metal bougies smeared with blue ointment have been employed with success. These are inserted into the urethra for a few minutes every third day. By means of a Kollmann intra-urethral probe, the end of which has been wound with absorbent cotton thickly covered with ointment, the application may be made without previous dilatation or the use of the endoscope. The applicator is gently passed into the urethra until the compressor urethræ muscle is reached. It is allowed to remain here for a minute or two, and then gradually withdrawn, being slowly rotated meanwhile so that the entire wall of the anterior urethra is medicated. When the application is to be made to the posterior urethra, a posterior urethral endoscope must be employed. Papillomata or polypi must be removed with curet or snare. Follicular urethritis may be treated locally by exposing the diseased orifice by means of the endoscope, evacuating any discharge with Kollmann's capillary aspirator, and then injecting any desired preparation into the structure of the gland by means of the cannula and syringe, also devised by Kollmann. In inveterate cases of follicular urethritis an attempt may be made to destroy the glands by means of the electrolytic pointed probe.

Lesions in the posterior urethra are treated in precisely the same manner as those found in the anterior portion of the canal. When the disease is localized to the deep urethra, the entire canal must be irrigated when it is desired to flush the urethra with any medicament. Applications of stimulating solutions or ointments are made by means of an applicator passed through a posterior endoscope. Frequently it may be found inexpedient to irrigate the prostatic urethra or to irrigate it by inserting the endoscope; in such cases instillations may be made by means of the Keyes-Ultzmann or Guyon syringe, injecting from five to ten minims of a 0.25 to 2 per cent. protargol solution, or a silver nitrate solution, 2½ grains to the ounce. Argyrol is valueless in chronic cases.

Occasionally local treatment in chronic cases is continued over too long a period. When the discharge persists in spite of treatment, this should be discontinued and efforts directed toward improving the patient's general health. Chronic gonorrhea may be followed by a urethrorrhea, which will disappear if treatment is omitted.

The marriage of one who has a chronic inflammatory lesion in the urethra or a suppurative discharge should never be sanctioned.

GONORRHEA IN THE FEMALE.

Gonorrhea occurs far more frequently among women than is generally believed. Any portion of the mucous surface of the genital apparatus may be the primary seat of infection, or, as rarely happens, it may, from the outset, be involved in its entirety. It is not unusual to find two distinct portions of the genital apparatus infected simultaneously. The inflammatory symptoms may be acute, subacute, or chronic.

Gonorrhea of the Urethra.—Except in children and young adults, the urethra is usually the first portion of the genital apparatus to be invaded by the gonococci, although the urethra and cervical canal may be affected simultaneously. The period of incubation is from two to five days. The attack begins with a burning, tingling sensation in the urethra, attended with a slight serous secretion. Later the symptoms become more acute. There is burning pain along the canal, especially during urination, the lips of the meatus are swollen and pouting, and there is a discharge of greenish-yellow pus that irritates the mucous membrane with which it comes in contact. The bladder soon becomes implicated and ardor urinæ occurs. When the urethra alone is involved, the two-glass urinary test will show the first urine to be cloudy and the second clear; if the bladder is affected, both will be cloudy. If the patient has urinated just before examination, no discharge will be discernible unless it is expressed from the canal by making pressure along the under surface of the urethra—a test known as "stripping the urethra." The symptoms subside in the course of a week, and a chronic urethritis may be set up.

A form of chronic urethritis is occasionally observed that resembles a similar condition attacking the deep urethra in the male. In this condition the urine is cloudy, and contains mucus, pus, and epithelium. Increased frequency of urination, pain in the sacral region, and vaginismus occur. Examination reveals a thickening of the mucous membrane, due to cell proliferation, with a fissure or erosion at the neck of the bladder.

Gonorrhea of the Os Uteri.—Next in frequency to the urethra the cervical canal is most often the seat of primary attack. This is a serious condition, because of the danger of the disease becoming latent. A gonorrheal infection of the neck of the uterus may be limited to the cervical canal, the process being inhibited at the os internum. When the affection becomes chronic, it is likely to become localized in the glands of Naboth; in this case there will be few, if any, appreciable symptoms. The discharge is frequently free from gonococci, but women so affected often transmit the infection. The cervix is generally infected primarily, but it is not uncommon to find it involved simultaneously with the urethra. It is only in the hyperacute cases that the infection extends backward and involves the uterus.

Invasion of the cervix uteri is generally very insidious, and there are no characteristic symptoms. In some cases there is a feeling of weight in the pelvis, a dragging sensation in the loins, or the uterus may be sensitive on palpation. Dysmenorrhea or metrorrhagia, together with a

slight increase in the leukorrheal discharge, may be the first symptoms. On vaginal examination nothing abnormal may be visible beyond a slight congestion, with a thick, glairy mucous discharge at the outlet, or the neck of the uterus may be swollen, red, and pouting, with erosions on the mucous membrane. This form of inflammation sometimes extends and involves the mucous membrane of the vagina surrounding the uterus. The cervix may be deeply eroded and of a purplish hue, in which case there is a thick, mucopurulent secretion that bathes the neck of the uterus and collects in the posterior portion of the vagina, giving rise to a localized vaginitis. When the glands of Naboth are involved, the cervix presents a nodular appearance, sometimes dotted with red elevations, thick plugs of mucus being adherent to the uterine outlet.

Gonorrheal Endometritis.—Gonorrhea of the uterus may be acute or chronic. A diagnosis can be made only from a history of the case and from the discovery of gonococci in the discharges. Usually there is a feeling of malaise, with slight fever, nausea, and vomiting. Pain is felt in the sacral region and is aggravated by motion. There is often a burning or bearing-down sensation in the pelvis. The vagina is hot, and the uterus is symmetrically enlarged and tender. The cervix is edematous and inflamed. In the early stages the discharge from the uterus will be mucopurulent; later it becomes purulent and frequently tinged with blood. Menstrual suppression or menorrhagia may occur.

It is frequently impossible to differentiate between a chronic inflammation of the uterus due to gonococcic invasion and one produced by other causes. A gonorrheal perimetritis is an especially dangerous condition, being prone to develop either during pregnancy or just after childbirth, and frequently giving rise to sepsis.

Chronic gonorrheal metritis, perimetritis, salpingitis, and **oöphoritis** are treated of elsewhere (see Vol. V).

Gonorrhea of the Vulva.—Gonorrheal vulvitis may be a primary or a secondary infection. It may involve the vulva alone, but is frequently complicated by urethritis and bartholinitis. It is most commonly seen in children and young girls, occurring as the result of rape or of the first attempt at coitus with a man suffering from a specific urethritis. The attack usually begins with an itching or an intense burning sensation of the external genitalia, accompanied by a mucoid discharge that rapidly becomes purulent and very profuse, causing an irritation of the cutaneous structures with which it comes in contact. Patches of dermatitis are not infrequently seen on the inner side of the thighs. If the discharge comes in contact with the anus, tenesmus of the sphincter ani results, the symptoms simulating fissure in ano. The labia become edematous and swollen. The mucous membrane covering the vulva becomes eroded. The passage of the acid urine over the eroded surfaces gives rise to severe pain and discomfort. The irritation about the clitoris frequently produces intense sexual excitement and even nymphomania.

Gonorrheal Infection of the Glands.—The structures most likely to become infected are Skene's urethral glands, the extra-urethral and para-urethral follicles, and the glands of Bartholin and of Naboth. This

form of gonorrhea is but little understood, and is not infrequently entirely overlooked or neglected.

Bartholinitis.—This affection may be either acute or chronic, and frequently complicates gonorrheal vulvitis. The earliest symptom is a feeling of pain and rigidity of the affected labium; a small mass develops in the lower portion of the vaginal orifice; this rapidly increases in size, and may attain the dimensions of a hen's egg. The swelling is red and sensitive. Congestion and edema are present. Pain is increased on exertion, and there may be mild rigor, with febrile reaction. Suppuration is the rule, the abscess rupturing near the orifice of the duct, and discharging a thick yellow pus that is frequently offensive and contains gonococci. The parts gradually assume their normal condition, leaving a sinus or a portion of the infected gland behind, which may become the seat of future abscesses and the avenue by which the infection may be transmitted. When the duct of the gland alone is involved, there may be no symptoms beyond a slight feeling of irritation in the part, and the patient may be unaware of her condition. The infection may extend to the gland, and an abscess forming on it may result in chronic adenitis.

Gonorrheal Vaginitis.—This condition is usually secondary to infection of the urethra or vulva. The inflammatory process may be acute, subacute, or chronic, and diffuse or localized. Any portion of the vagina may be involved. In the *acute* variety there is at first an uneasy, burning sensation in the vagina, attended by a mucopurulent discharge that soon becomes purulent. Edema and erosion of the folds of mucous membrane at the entrance of the vagina occur. When the entire structure is inflamed, especially if urethritis or vulvitis is also present, the patient's sufferings are intense. The mucous membrane of the vagina becomes so swollen and tender that local treatment is impossible until the hyperacute symptoms subside.

In the subacute stage the discharge is scantier and more mucoid in character, becoming localized to one or more patches on the mucous surface.

In *chronic* vaginitis the mucous membrane becomes thickened and granular, and a catarrhal discharge occurs that is generally mistaken for leukorrhea.

Treatment.—The treatment of gonorrhea in women is usually a very unsatisfactory procedure. The acute invasion is frequently so mild and subsides so quickly into either a subacute or a chronic condition that it is often impossible to impress such patients with the necessity of submitting to the tedious course of local treatment required to effect a cure. The appearance of the catamenia interferes with treatment and delays convalescence.

Gonorrheal Urethritis.—The administration of the balsamic remedies or of genito-urinary antiseptics is indicated only when either the urethra or the bladder is involved. An uncomplicated case of urethritis in the female is treated on exactly the same lines as a similar infection in the male, with the exception that the topical remedies should be stronger and that the glass hand syringe employed should not have a capacity

of over one dram. If cystitis, vulvitis, bartholinitis, or vaginitis develops, local treatment must be discontinued until the acute symptoms have subsided. When there is a hyperacute urethritis, the treatment consists of frequent hot sitz-baths and vaginal irrigations with potassium permanganate solution. *No urethral medication should be undertaken until all acute symptoms are under control.*

When the affection becomes chronic, the lesions somewhat resemble those seen in the male urethra in a similar condition and demand the same treatment. If the urine contains pus and mucus, the balsamic remedies should be continued. Ointments of one of the newer silver salts should be applied to the diseased surface about every third day with the aid of the endoscope. When there is a periurethral infiltration, with a fissure at the neck of the bladder, the vesical erosion should be touched with a bit of cotton wound on the end of an applicator, moistened with a solution of silver nitrate, five grains to the ounce, and passed through an endoscope. A soft-rubber catheter should then be inserted and the bladder irrigated with 1 : 10,000 silver nitrate solution, gradually increasing the strength of the solution as the indications demand. A short steel bougie should next be inserted, and allowed to remain in the urethra for two or three minutes. Stricture of the urethra is treated by gradual dilatation.

Gonorrhea of the Os Uteri and Uterus.—The sole treatment for a gonorrheal infection that involves only the os uteri or the uterus consists in dilatation and curettage of the cervical canal and the cavity of the uterus. After the curettage the vagina should be douched twice daily with either a bichlorid or a potassium permanganate solution. If any evidence of the affection is found about the cervix after the operation, this should be treated with local applications of one of the silver salts, preferably silver nitrate. Ichthyol is also very serviceable at times as a topical application. If the uterine adnexa are diseased, the curettage should be followed at once by abdominal section and removal of the diseased appendages.

Gonorrheal Vulvitis.—Rest and a restricted diet should be ordered and the bowels moved freely with the aid of salines. The urine should be rendered unirritating by the internal administration of potassium citrate and alkaline mineral waters. Cleanliness is absolutely essential. If the hair about the pubes becomes matted, it should be shaved off and the secretion washed away with a stream of hot normal salt solution, care being exercised to prevent the discharge from being driven into the vagina or urethra. The part is then sprayed with hydrogen dioxid and afterward irrigated with salt solution. The inflamed surface should then be brushed over with a 20 per cent. solution of argyrol, followed by an irrigation of 1 : 5000 mercury bichlorid solution, or potassium permanganate, 1 : 2000, after which sterilized gauze, moistened with either solution, may be kept constantly applied to the part, the dressing being held in place by means of a T-bandage. If the symptoms become very acute, and there are swelling and pain, lead-water and laudanum should be applied. If there is marked edema, multiple punctures, under strict

asepsis, should be made, penetrating merely through the cutaneous surface. This procedure is frequently followed by immediate relief from pain and the subsidence of the swelling. When the symptoms abate, a boric-acid solution may be substituted for the mercury bichlorid or potassium permanganate solution. When the condition becomes chronic and localized, irrigations of weak solutions of mercury bichlorid should be ordered twice daily, and local applications, either of silver nitrate (20 grains to the ounce) or of protargol (2 grains to the ounce), be made to the lesions about once every third day. When the patient is convalescent, a dusting-powder, consisting of zinc stearate, talc, or bismuth, is to be applied, the labia being separated by means of sterilized absorbent cotton.

Gonorrheal Bartholinitis.—If the patient is seen during the early stage, before suppuration has occurred, the gland, together with the duct leading to the glandular tissue, should be resected. If suppuration has taken place, the abscess should be incised on the inner surface of the labia, and the gland, as well as its duct, destroyed by means of a curet and phenol, or, what is preferable, both structures should be completely resected, and the wound washed with hydrogen dioxid, irrigated with mercury bichlorid solution, packed with iodoform gauze, and allowed to granulate. Attempts to obtain union by first intention in such cases are futile. When the gland is enlarged and indurated, it should be resected by making an incision through the skin surface, closing the wound later by means of interrupted sutures.

Gonorrheal Vaginitis.—In mild cases the vagina should be douched night and morning with at least a gallon of a warm solution of corrosive sublimate 1 : 4000, gradually increasing the strength to 1 : 2000; or potassium permanganate may be employed, beginning with a 1 : 4000 solution and increasing to 1 : 1000. After this two drams of hydrogen dioxid should be injected, and then washed away with a quart of normal salt solution. The entire mucous surface should next receive an application of a 20 per cent. argyrol solution, and a tampon wet with the same may be inserted and left in place until the next irrigation is to be performed. In the course of a few days a 1 per cent. protargol solution should be substituted for the argyrol. In about ten days or two weeks the inflammation will become localized to one or more patches on the mucous membrane of the vagina. Irrigations with creolin, or preferably with 1 per cent. lysol solution, should now be made, followed by local applications of silver nitrate solution, 30 grains to the ounce, or 1 per cent. protargol solution, the applications being made with the aid of a speculum. After this a vaginal tampon of wood-wool, soaked either in ichthyol or in boroglycerid, should be inserted.

A chronic granular condition of the mucous surface, most commonly affecting the posterior segment of the tube just behind the cervix, should be treated by means of a vaginal douche of 1 : 20,000 mercury bichlorid solution, after which the woman should be placed in the knee-chest position and a Sims speculum introduced. The inflamed area should now be touched with the silver preparation, and a five-grain ichthyol vaginal

suppository inserted. When the inflammatory process is very acute, and a considerable portion of the tube is affected, local treatment is impossible until the symptoms begin to abate. The patient is kept in bed and a brisk purgative administered. Hot rectal injections, sitz-baths, and the local application of lead-water and laudanum, make up the treatment. The vulva and the orifice of the vagina may be painted over with a 10 per cent. solution of argyrol; about 1 dram of this may also be injected very gently into the tube by means of a small hand syringe, or by the insertion of a well-lubricated small rubber catheter. As soon as feasible, local treatment should be instituted.

GONORRHEAL OPHTHALMIA.

This is, fortunately, not a very common disease. It may be defined as a violent purulent conjunctivitis, caused by infection of the conjunctival sac by gonococci. The most common mode of infection is through contamination brought directly from the urethra to the eye; not infrequently, also, either as the result of accident or of carelessness on the part of the attendant, the infection is transmitted from the diseased to the sound eye. In the new-born infant the affection occurs by inoculation from the gonorrheal discharges about the genitals of the mother during the passage of the child.

Symptoms.—As a rule, the onset is so rapid that the inflammatory symptoms are in the acute stage when the patient applies for treatment. The symptoms usually appear very shortly after infection, and consist of itching and a feeling of irritation about the eye, similar to that experienced when a foreign body is embedded in the conjunctiva. There is a free escape of lacrymal fluid, and the mucus collects in the inner canthus, gluing the eyelashes together. The conjunctiva, by this time, is markedly congested. The mucoid secretion soon becomes purulent and runs down the cheek, being diluted from time to time with the abundant watery secretion coming from the lacrymal gland. The irritating discharge frequently causes a dermatitis of the skin surrounding the eye.

The inflammatory process first affects the inner surface of the eyelids, and rapidly involves the entire conjunctival sac. The eye assumes a deep-red, angry appearance, with swelling of the membrane and eversion of the lids, forming a thick border around the cornea—a condition known as "chemosis." The eyelids become swollen, the upper lid being markedly discolored and overlapping the lower. Photophobia is frequent. Chemosis may interfere with the circulation of the cornea, causing strangulation, and, as a result, there may be a localized ulceration or a sloughing of the entire cornea, with the discharge of the crystalline lens.

In true gonorrheal ophthalmia the outlook is very grave. If the case is early brought under the care of a skilful ophthalmologist, the prognosis is somewhat brighter. Ulceration of the cornea leaves the vision more or less permanently impaired.

Treatment.—The patient should be isolated in a moderately darkened, well-ventilated room, under the supervision of a day and a night nurse,

for constant care and attention are necessary to insure successful treatment. The attendants should be warned of the infectious nature of the disease. If but one eye is infected, the other should be protected by means of a Buller's shield. Frequently repeated irrigations should be begun at once. These may consist of mercury bichlorid solution, 1 : 10,000, mercury cyanid, 1 : 5000, and boric acid. The first two remedies mentioned are not germicidal in a strength that it is safe to employ in eye infections, and consequently serve only as cleansing agents. De Schweinitz recommends a stearated solution of boric acid, which "fulfils both purposes of being safe and cleansing." *If the cornea is not involved*, compresses soaked in ice-water should be applied to the swollen eyelids, changing them every half-hour or less often, according to the effect produced. They may be used almost continuously for two or three hours. The conjunctival sac may be kept continually floated in a 5 per cent. argyrol solution, by what de Schweinitz calls the "immersion method"; by this means "the conjunctiva is kept constantly bathed in the solution, which is bland, unirritating, and materially aids *in bringing to the surface from the hidden folds of the swollen conjunctiva the purulent secretion.*" Silver nitrate is useful, being astringent, caustic, alterative, and germicidal. The sac is first irrigated and all pus and lymph washed away. Both lids are everted so as to obtain full exposure of the swollen tarsal conjunctiva. *With a small cotton mop* dipped in a *freshly* prepared 2 per cent. silver nitrate solution, the conjunctiva is gently but thoroughly painted until a white film forms. Irrigation with normal salt solution is now employed until this film is completely washed away. The ice compresses are then reapplied for about ten minutes. This application should be made once daily. If this mode of treatment fails to produce the desired effect, irrigation with copious solution of potassium permanganate 1 : 2000 or 1 : 5000 should be employed three or four times daily after the manner of Kalt (de Schweinitz).

Marked chemosis is best treated by scarification, making radial incisions with a Graefe knife from within outward through the entire depth of the swollen tissue. Care should be observed not to wound the cornea. As soon as the operation is completed the conjunctival sac should be irrigated with a saturated boric-acid solution until bleeding ceases. When the swelling is so great that the eyelid cannot be everted, some surgeons advise free division of the outer commissure and of the canthal ligament. Severe edema of the eyelid may be relieved by making minute punctures in the skin. From the first, a solution of atropin should be dropped into the eye for the purpose of relieving pain by lessening intraocular tension and tending to keep the iris free from adhesions. As convalescence sets in the eye should be shaded from the light, the silver solution being gradually reduced in strength, and ordinary astringents, such as alum or zinc in weak solutions, substituted.

DISEASES OF COWPER'S GLANDS.

These glands are the analogue of the gland of Bartholin in the female. In the normal condition the glands cannot be detected on palpation. When enlarged or inflamed, however, they can easily be distinguished by inserting the index-finger into the rectum and placing the thumb upon the perineum of the affected side. Gentle manipulation will express any pathologic secretion they may contain into the urethra, from which canal it can readily be secured for microscopic study.

Inflammation.—Cowperitis may be due to a secondary infection the result of typhoid, endocarditis, measles, and pyemia; as a rule, however, it is due to a gonococcic infection of the urethra; it is also occasionally associated with a prostatitis. A gonorrheal inflammation of Cowper's glands may occur as early as the third week after the onset of a urethritis or not until a much later period. The most common mode of onset is the sudden development of acute localized symptoms that soon result in the formation of an abscess. In some cases the patient's resisting power to microbic invasion seems to be so great that a low grade of inflammation results, the development of the characteristic symptoms being gradual, the gland remaining enlarged, and considerable hyperplasia taking place before suppuration sets in. In the acute form a small, painful mass is felt in the perineum. Pain is aggravated by motion, pressure, the sitting posture, or defecation. Spasm of the compressor urethræ muscles renders the termination of urination painful. Frequently dysuria is present, and at times retention occurs. When suppuration occurs, the swelling increases in size. When the pus is deep-seated, the symptoms resemble those of cellulitis. The perineal and scrotal swelling is hard, tense, red, and brawny, the skin is hot and tender to the touch, and there is no evidence of fluctuation. A small abscess may form in the substance of the gland, discharging its contents through the duct into the urethra, a cure being effected by a gradual obliteration not only of the gland, but of the duct as well. This fortunate termination is rare; more commonly there remains a small hard lump on one side of the median line of the perineum, which is a constant source of menace to the individual, making recurrence possible, and leaving the patient liable to transmit the disease during coition.

At times a cowperitis is chronic from the beginning. The gland slowly enlarges until the tumor may reach the size of a walnut; it is only slightly sensitive. This condition may persist for two months or more before suppuration takes place. During an acute attack of cowperitis the urethral discharge either ceases temporarily, or is very much diminished in quantity, only to become profuse again when the acute inflammatory symptoms subside. A chronic cowperitis may result in a hypersecretion of mucus, causing a constant mucoid discharge that, as the result of pressure, may appear at the meatus as a clear drop, gluing together the lips of the orifice. The urethra is normal. The urine will also be normal and clear, occasionally showing the presence of slight amounts of

mucus. A bacteriologic examination of the secretion will prove negative; at times a few epithelial cells may be found.

As a rule, constitutional symptoms are mild or absent. When there is quite an extensive abscess, there may be a slight rigor and a febrile reaction. When the pus is deep-seated, there will be a decided rise of temperature.

Treatment.—The only treatment is *immediate operation.*

In cases of small abscesses of the gland that drain into the urethra resection should be done. A large perineal or scrotal abscess should be freely incised and drained, the diseased gland being removed at the same time. When the pus is deep-seated and there is cellulitis of the perineum, the inflammatory tissue should be incised and the dissection continued until the focus of pus-formation is reached. Gangrenous cellular tissue should be removed if possible. In all suppurative cases, after the pus has been evacuated, the wound should be flushed with hydrogen dioxid, irrigated with a 1 : 1000 mercury bichlorid solution, packed with iodoform gauze, and the abscess cavity allowed to heal from the bottom up. If the abscess has ruptured before the patient is seen for the first time, and a fistula leading down to the diseased structure remains, with more or less hyperplasia, the sinus should be freely opened and the diseased tissue removed. The fistula, together with the remnant of the diseased gland, should be dissected out. The margins of the fistulous opening in the urethra should be freshened, the opening then being closed by means of interrupted fine catgut sutures, a soft-rubber catheter being inserted through the urethra into the bladder, thus draining off the urine until the wound in the urethra has healed. No attempt should be made to close the urethral fistula until the urethritis has disappeared. Cubebs, copaiba, and sandalwood may be administered with advantage immediately after the operation. Local treatment is not to be resumed until the patient is convalescent from the effect of the cowperitis.

Tuberculosis.—This is a very rare affection; when it does occur, it usually results from a tuberculous urethritis. The disease develops insidiously, with a painless enlargement of the gland.

The only **treatment** is operative. The infected area should be resected and the curet employed; the wound should be flushed with hydrogen dioxid, followed by irrigation with a mild mercury bichlorid solution, after which phenol should be applied to the affected surface and the wound swabbed with sterilized absorbent cotton saturated with alcohol, and then packed with iodoform gauze.

Tumors.—They have been observed only in the form of cysts and of carcinomata. In carcinoma the only treatment is early and complete removal. When the tumor is inoperable, the treatment should be palliative.

STRICTURE OF THE URETHRA.

Stricture of the urethra may be either temporary or permanent, congenital or acquired. The temporary form is either inflammatory or spasmodic in nature, whereas the organic form is due to pathologic

changes affecting the structures that make up the wall of the urethra.

The **congenital** variety is rare, its site being either the region of the meatus or the bulbomembranous junction of the urethra. The only treatment for this form of stricture is early operation.

An **acquired** stricture may be inflammatory, spasmodic, or organic in nature.

Inflammatory strictures are usually of the temporary variety, being associated with an acute urethritis that gives rise to an edema of the mucous membrane, together with the formation of a recent soft plastic exudate in the periurethral tissue that interferes with the dilatability of the canal and diminishes its caliber. The obstruction usually disappears as the inflammatory process subsides; the cellular infiltrate may, however, become organized into fibrous connective tissue, resulting in the formation of an organic stricture. Retention of urine the result of an inflammatory stricture is rare; when it occurs, it is due to muscular *spasm*.

The obstruction of the urethra from **spasmodic stricture** is the result of contraction of the muscular fibers of the canal, the accelerator urinæ, or the constrictor muscles. Not uncommonly it arises from reflex causes, such as a contracted meatus, hyperesthesia, inflammatory lesions of the urethra, or diseases of the rectum or neighboring structures. Muscular spasm frequently exists as a complication, especially in strictures of large caliber.

An **organic stricture** is due to the formation of a cell proliferation either within or around the walls of the canal, gradually becoming converted into a fibrous connective tissue that, as it contracts, narrows the lumen of the urethra and interferes with its dilatability. The submucous tissue is the structure most commonly involved. After a fibrous stricture has once formed, the urethra can never again be restored to its normal condition. In spite of dilatation or incision of the coarctation a certain amount of rigidity remains, which frequently increases with age, thus explaining the difficulty often experienced in attempting to dilate a stricture in elderly men.

Organic stricture is the result either of inflammation or of traumatism. Urethral chancre, tuberculous ulcers, and neoplasms are sometimes responsible for the contraction. Most cases, however, occur as sequels of gonorrhea. It may be single or multiple, the latter not being so common as is generally believed. I have found almost the entire anterior urethra from the meatus down to the bulb contracted in several instances.

Organic strictures are most common between the ages of twenty and fifty years. A stricture may involve any portion of the urethra, but shows a predilection for the region adjacent to the bulbomembranous junction.

A stricture of the membranous urethra is nearly always traumatic in origin. A coarctation of the prostatic portion is so rare as to possess but little clinical significance. It has been observed as a complication of fracture of the pelvic bones.

Varieties.—The form known as a *bridle stricture* is a mere membranous band, stretching across the urethra and narrowing its caliber.

An *annular stricture* encircles the canal, narrowing its lumen, just as if a thread had been tied about the part. In an *indurated* or *nodular stricture* a thick, hard mass can be felt embedded in the corpus spongiosum, at the site of contraction. This form of obstruction is always indicative of a previously existing gonorrheal infection. When the periurethral cell infiltration is of recent origin, organization not yet having taken place, the condition is known as a *recent* or *soft stricture*. An *irritable stricture* is one in which pain, hemorrhage, and urethral fever follow the insertion of an instrument, in spite of antiseptic precautions and care. A stricture that contracts rapidly even after full dilatation or urethrotomy is known as a *resilient* or *recurring stricture*. It occasionally results from gonorrheal infection, but more frequently follows traumatism. A *permeable stricture* is one in which an instrument may be successfully passed through the obstruction, differing in this respect from an *impermeable stricture*.

Complete occlusion of the urethra is extremely rare. I have encountered it only in a few instances, in which it occurred in conjunction with traumatic strictures. In these cases the urethra was completely obstructed by a fibrous exudate, the urine being passed through a fistulous opening behind the obstruction.

A stricture that is hard, dense, and fibrous, occasionally being even cartilaginous, is known as a *cicatricial stricture*. Traumatic strictures are usually of this variety. When the opening through the stricture is directly in the center of the coarctation, the condition is known as a *centric stricture*. As a rule, however, the aperture is "**eccentric,**" being situated near the floor, the roof, or to one side of the median line of the urethra. Finally, strictures are classified as those either of *large* or of *small caliber*. As a rule, a stricture having a caliber smaller than No. 5 of the French scale is regarded as of "**small caliber.**"

The time necessary for the development of strictures varies according to the exciting cause. Those of gonorrheal origin develop very slowly, months, or even years, passing before obstruction occurs. In rare cases strictures will develop within a year after a specific urethritis. When due to traumatism, the contraction begins to take place as soon as the wound has healed.

Pathology.—In long-standing cases of subacute urethritis it is not unusual to find an extensive periurethral cell infiltration, which becomes only partially organized, causing but a slight contraction of the lumen of the canal, but interfering materially with its dilatability, giving rise to congestion of the blood-vessels in the affected area. As this form of cellular exudate seldom becomes converted into a fibrous connective tissue, the development of an organic stricture under these conditions is the exception, rather than the rule, the plastic lymph being readily absorbed as the result of judicious urethral dilatation. When a new cell development infiltrates a localized portion of the urethral walls, it may undergo organization and become converted into scar tissue. This change is a very gradual one, a long period of time elapsing before characteristic symptoms arise. A stricture of this type is usually one of "**large caliber.**" It is obvious that all strictures must be of large caliber at the

onset, and may remain unchanged for years, often producing but slight symptoms. Not infrequently, however, reflex disturbances occur, such as irritable bladder, hyperesthesia of the urethra, nocturnal seminal emissions, and atonic impotence, or an intractable form of urethral catarrh may occur. On the other hand, a stricture of large caliber may, after a short time, become so much contracted as scarcely to permit a filiform bougie to be passed through the opening.

Many writers, notably Guyon and Finger, believe that chronic gonorrhea is the cause of organic stricture. This is by no means the etiologic factor in every case, since cases of long-standing chronic urethritis are not infrequently seen in which stricture is absent. More or less chronic urethritis is always associated with a stricture of either large or small caliber, the inflammatory process caused by the obstruction of the urethra subsiding as soon as the constriction is relieved. Harrison believes that ulcerations and erosions of the mucous membrane of the urethra the result of a chronic gonorrhea permit a small quantity of urine slowly to permeate and infiltrate the submucous structure, producing a low grade of inflammation at the point at which the leakage occurs, this in turn giving rise to a cell proliferation that finally becomes organized into a connective tissue, and results in the formation of stricture. This view is tenable only in a certain proportion of such cases, as it is not uncommon to see either erosions or ulcerations of the mucous membrane that have existed for a long period of time and that were not accompanied by any evidence of coarctation. The theory advocated by Casper that any cause, microbic or otherwise, that is capable of causing a urethritis, in which a peri-urethral cell infiltration takes place, is likely to be followed by organic stricture, seems to be founded on the most rational and scientific basis. The morbid inflammatory changes resulting from gonorrhea are more likely to invade the deeper structures and affect a wider area than those resulting from the simpler forms of urethritis, in which only the superficial layers of the urethra are likely to be involved. It is for this reason that a stricture is so frequently associated with a chronic gonorrheal urethritis.

As a result of urethritis, the pathologic changes that take place either in or around the walls of the urethra are precisely similar to those observed in any other structure of the body as the result of an inflammatory process.

The central portion of a stricture consists of a dense fibrous tissue, whereas the margins are not so highly organized, and are frequently much softer and more pliable, and associated with a dilatation of the blood-vessels giving rise to congestion and a localized chronic urethritis. The affected area is occasionally the seat of superficial erosions, ulcerations, or papillary growths, which are likely to bleed freely when instrumentation is attempted. The mucous membrane in the region of a stricture becomes hard and thickened. The superficial layer of the epithelial cells undergoes necrosis, and on exfoliating appears in the urine as characteristic threads of various sizes and shapes. The glands of Littré may be either partially or completely destroyed by the inflammatory process.

When an extensive portion of the corpora cavernosa is involved in the tissue changes the result of inflammation, the penile urethra is felt as a hard, rigid tube, and the urethra in such cases is obstructed from the meatus to the bulb. Should the newly formed connective tissue invade the mucous membrane, it may give rise to a septum—the so-called "bridle stricture"—or to the formation of a fold of tissue that acts like a valve. In cases of ordinary stricture but few pathologic changes beyond those that take place in the urethral mucous membrane will be observed. Occasionally, when the obstruction has persisted for years, the wall of the urethra, as the result of an atrophy of its tissues, becomes thin. A dilatation or a pouch may form, both in front of and behind the coarctation. The posterior dilatation permits decomposed urine to accumulate, resulting in a low grade of urethritis, attended by the formation of erosions and ulcerations which permit a small quantity of urine to leak into the periurethral stricture, giving rise to abscesses that, when evacuated, result in the formation of perineal or scrotal urethral fistula. The dilatation of the urethra anterior to the stricture is caused by a gradual atrophy and absorption of the portion of the stricture that is not exposed to the constant irritative effect of the decomposed urine. The mucous membrane in such cases is of a pale, dirty-white color, and does not present the appearance of a chronic urethritis. Should an obstruction to the urethra caused by stricture be permitted to remain unrelieved, certain secondary pathologic changes may gradually take place in the urethra, bladder, ureters, and kidneys, which may in turn be followed by a hypertrophy of the muscular structures of the heart, ureters and bladder. In elderly subjects the latter condition sometimes undergoes a fatty degeneration, rendering surgical procedures dangerous.

Complications.—Fenwick has observed that a stricture of small caliber is always associated with retention of more or less residual urine. In the majority of cases the amount will vary from three to five ounces. When ten ounces are retained, extensive changes in the ureters and kidneys are usually present, and internal urethrotomy, in such cases, is generally attended by a large mortality.

In neglected cases, the bladder, ureters, and kidneys may become involved. Atony of the bladder may result from sudden retention of urine in those cases in which the urinary obstruction is due not only to a stricture, but to senile hypertrophy of the prostate as well. In the latter condition the bladder usually remains either partially or completely paralyzed, even after the obstruction has been removed. By far the most common change that the bladder undergoes is a hypertrophy of its walls and a lessening of the capacity of the organ, so that it will not hold more than three ounces of urine. This condition is known as a "compensating hypertrophy." Ridges or bars made up of thickened mucous membrane and muscular tissue form; the violent spasmodic contractions of the muscles drive the mucous membrane down between these partitions, giving rise to the formation of numerous pouches in which decomposed urine accumulates, greatly aggravating the existing cystitis and serving as a seat for the formation of calculi. The ureters may become inflamed,

thickened, distorted, and sometimes obstructed. Hydronephrosis, pyelonephritis, and multiple abscesses of the kidneys are late complications.

Symptoms.—The subjective symptoms are: change in the character of the stream; frequency in micturition; dribbling of urine; ardor urinæ; tenesmus; retention of urine; and, in some cases, a chronic urethral discharge. The urine is cloudy, owing to the presence of pus, mucus, and epithelial shreds. Sexual irritability and atonic impotence may be associated with a stricture of large caliber, whereas one of small caliber, especially if situated at the bulbomembranous junction, may result in aspermatism. In long-standing cases in which the bladder, ureters, and kidneys are diseased and urinary changes have taken place, marked constitutional symptoms will frequently occur, such as chronic urinary fever, septicemia, or uremia, which may be associated with a polyuria or a suppression of urine.

A stricture of either large or small caliber may exist for a considerable length of time without giving rise to any characteristic symptoms. Of the various symptoms previously enumerated, one or all of them may be present in the same patient. In most cases of stricture of the urethra the history will disclose the fact that the patient had previously had a chancre or chancroid, an injury of the urethra, or frequent attacks of relapsing chronic urethritis.

A change in the character of the stream is by no means a constant symptom, nor does its existence always indicate stricture of the urethra, the size, shape, or a malformation of the meatus being at times responsible for the impeded current. In some cases there may be no interference with either the volume or the course of the urinary stream; in others the stream may be forked, twisted, spray-like, or diminished in volume.

Increased frequency of urination is usually an early symptom, and generally develops insidiously, at first giving rise to but slight discomfort, and hence attracting but little attention. Gradually a urethrocystitis develops, and the frequent desire to void urine becomes very annoying. At first the increased desire to urinate occurs only by day; when, however, atony of the bladder exists, with the presence of residual urine, the desire to urinate is both diurnal and nocturnal, simulating a condition associated with urinary obstruction caused by hypertrophy of the prostate.

When a stricture of small caliber, with atony of the bladder, remains unrelieved, there may be great difficulty and delay in emptying the bladder, the urine being voided only as the result of straining and bearing-down efforts. It flows in a small stream, the normal parabolic curve being lost. The constant straining soon causes muscular fatigue, and thus the act is constantly interrupted, a considerable time being required to empty the bladder. The patient may assume the sitting posture during urination, utilizing the muscles of the abdomen and perineum in his efforts to assist the weakened bladder to expel its contents. An unrelieved obstruction of long standing, in which constant straining is necessary to empty the bladder, is prone to be complicated by the development of hemorrhoids and anal fissures, which greatly augment the patient's suffering.

Diminution in the expulsive power of the bladder is a late symptom, and may be attended by either an atony of the bladder, associated with the accumulation of residual urine, or a hypertrophy of the muscular walls of the viscus and a diminished capacity. An early, and frequently an annoying, symptom is the leakage of a few drops of urine after the act of urination is believed to have been completed.

In long-standing cases the urethra behind the stricture becomes dilated and forms a funnel-shaped pocket; the urine contained in this pouch is not expelled during micturition, and slowly percolates through the narrow opening in the coarctation until the reservoir is emptied. Another late symptom of stricture is incontinence of urine, a condition always associated with atony of the bladder. This is, in reality, a form of *retention*, the constant dribbling of urine being the "incontinence of retention."

Ardor urinæ is not observed except in cases that are complicated by an acute attack of urethrocystitis. It is a transitory symptom, subsiding as soon as the inflammatory manifestations begin to abate, but recurring whenever the patient is exposed to cold, unusual fatigue, or alcoholic or sexual indulgence.

Actual pain is not, as a rule, present in stricture unless a localized inflammatory condition also exists; it is not unusual, nevertheless, for patients to complain of a scalding, burning sensation during urination or a feeling of weight or aching in the testicles. In cases of tight stricture of the deep urethra a seminal discharge is frequently associated with very severe burning pain, which occasionally is of a lancinating or "tearing" character. Vesical tenesmus sometimes occurs in conjunction with cystitis. It may be mild or cause intense agony.

Diagnosis.—This may be made from what Guyon has termed the "urethral history" of the case. A bacteriologic, chemic, and microscopic examination of the urine will demonstrate the variety of the microbic flora present, and will also reveal the presence of any pathologic condition of the bladder or kidneys. By direct examination of the urethra the location, caliber, and number of strictures can be definitely determined.

Before attempting exploration of the urethra an effort should be made to ascertain the normal caliber of the canal. This may be determined from the following table:

WHITE'S SCALE.

Circumference of Penis	3	inches.	Caliber of Urethra,			26 to 28	millimeters
" " "	3½	inches.	"	"	"	29 to 30	"
" " "	3¾	inches.	"	"	"	30 to 32	"
" " "	3¾	inches.	"	"	"	32 to 34	"
" " "	4	inches.	"	"	"	34 to 36	"

The instruments required for determining the location and caliber of a stricture are a conical steel bougie, bulbous bougies, the so-called bougie à boule, an Otis urethrometer, filiform bougies, Gouley's tunneled catheter, and the endoscope. The bulbous bougies may be made of steel or vulcanized india-rubber, and may be rigid or flexible. The former are employed for exploring the anterior, and the latter the posterior, urethra in strictures of large caliber. The urethrometer possesses two advantages:

it permits the location of strictures of large caliber in the anterior urethra to be determined with the insertion of only one instrument; whereas if a bougie à boule is employed, it is necessary to introduce, remove, and reintroduce several instruments before the required information is obtained; moreover, in order to insert the bulbous bougies of different sizes, it may be necessary to enlarge the meatus, a step that is not required if the urethrometer is employed.

A stricture of small caliber may readily be diagnosed by introducing a conical steel bougie (No. 16 French) into the urethra until its progress is arrested by contact with the coarctation. The portion of the shaft that protrudes from the urethra is grasped firmly between the index-finger and thumb, and the instrument withdrawn, a measurement being made from the point on the staff that was grasped by the fingers down to the beak of the instrument; this gives the distance of the obstruction from the meatus.

To determine the caliber of tight strictures, if a No. 16 bougie fails to pass through the constriction, an attempt should be made to insert one 15 mm. in thickness; should this also fail to pass, the next size smaller should be tried, and so on, each unsuccessful attempt being followed by the insertion of an instrument one size smaller than its predecessor, until one is finally found that will comfortably pass the obstruction and thus give the desired information. If either a metal or a rubber bougie can be passed, much valuable information may be obtained by inserting a filiform and threading a Gouley tunneled catheter over this; this will usually indicate that the obstruction has become contracted to the caliber of the filiform, and can probably be relieved by gradual dilatation. The flexible whip bougie with metal shaft attachment designed by Fought can also be employed in a similar manner.

If it is found impossible to pass any instrument, a urethroscope should be gently introduced into the urethra as far as the seat of obstruction, when the surgeon may be able to see the orifice through the stricture, and thus, by the aid of direct vision, guide the filiform through the constricted portion.

For locating the seat of strictures of large caliber the Otis urethrometer or the metal or flexible bulbous bougies may be employed.

In the hands of the inexperienced, the urethrometer or bulbous bougie is a very unreliable instrument, being apt to lead to the formation of erroneous conclusions. The passage of a conical steel bougie is accomplished with the production of far less pain and irritation than accompany the insertion of the bulbous instrument. It must be remembered that the urethra does not possess a uniform caliber throughout, but is made up of a series of physiologic constrictions and dilatations and fixed and movable curves. The differentiation of a spasmodic from an organic stricture may give rise to perplexity at four points along the course of the urethra. These are, mentioned from before backward: just behind the meatus; at a depth of about four inches from the urinary outlet; at the bulbomembranous junction, and, finally, at the junction of the membranous and prostatic urethra.

A bulbous bougie, a size or two larger than the lumen of the meatus, will easily dilate the normal constriction of the orifice and permit its insertion into the canal; when the attempt is made to withdraw the instrument, the shoulder of the bulb will be caught at the constricted outlet and impart a sensation to the hand of the observer similar to that produced by a stricture, although in reality no pathologic condition exists. The beak of the instrument descends into the canal to a depth of about four inches, when, particularly if it is passed by a nervous, uncertain, unsteady hand, the accelerator urinæ muscles will be thrown into spasm, causing a temporary spasmodic stricture that is frequently mistaken for an organic one. Just as the instrument leaves the bulb to pass into the membranous urethra it encounters the compressor urethræ muscles, which are frequently extremely irritable and easily excited reflexly, so that they contract firmly and prevent the instrument from passing, making a differential diagnosis between the organic and the spasmodic form of stricture in this situation difficult. In most cases of spasmodic stricture, if the end of the bougie is held firmly but gently against the site of obstruction for a minute, the spasm will gradually relax, allowing the instrument to be passed onward toward the bladder. In some instances the spasm will persist and the condition be mistaken for a filiform stricture; in these cases it will not rarely be found that a subsequent attempt to insert a bougie will be successful, the instrument gliding along the entire course of the canal without meeting any obstruction. Finally, as the bulb of the bougie passes from the fixed curved of the membranous to that of the prostatic urethra, it may become arrested by coming in contact with the posterior leaflet of the triangular ligament, which surrounds this portion of the canal.

As the result of chronic gonorrhea, induration, and thickening about the bulb, a stricture of large caliber is very frequently encountered. The method of introducing the flexible bougie à boule into the urethra is the same as that employed in introducing any other form of rubber instrument. When an atresia of the meatus exists, a preliminary meatotomy should be performed. The size of instrument to be used for exploration is determined by referring to the table on p. 545, giving the relation between the circumference of the middle of the body of the flaccid penis and the caliber of the urethra. The instrument is passed along the urethra until the bladder is reached; if, on withdrawing the instrument, an obstruction is encountered, the point on the shaft on a level with the meatus is marked off, and the measured distance from this fixed point down to the bulb of the instrument will indicate the site of the obstruction. The caliber of the urethra is determined by inserting different sized bulbous bougies until one is found that will readily pass the obstruction without being caught. Its size is determined by measuring it on a scale for urethral instruments constructed for this purpose. Care must be observed not to confound the obstruction due to urethral spasm caused by irritation or pain with that due to organic stricture.

At a first examination it is sometimes impossible to differentiate between a urethral obstruction due to spasm and one caused by an organic

stricture. Either condition may exist independently of the other, although it is not uncommon, especially in strictures of small caliber, to find spasm present as a complication. When this condition pertains and repeated efforts to insert the various forms of dilators, rubber instruments, or filiform bougies have been unsuccessful, it may be found possible to pass a conical steel bougie that comfortably fills the meatus.

When, in cases of organic stricture complicated by spasm, it has been found impossible, after a fair trial, to pass any of the various forms of urethral instruments, the wisest plan is to desist from further attempts at urethral instrumentation for at least forty-eight hours, except in emergency cases; in the latter the surgeon should perform the necessary operation required for relief at once. During the interval between the examinations the patient should be freely purged, and a mixture of belladonna, sodium bromid, and potassium citrate administered. Before urethral instrumentation is again attempted a dram of a 2 per cent. cocain solution should be injected into the urethra and retained for ten minutes; the canal should then be gently irrigated with a warm solution of boric acid, followed by an injection consisting of a teaspoonful of a 10 per cent. emulsion of iodoform suspended in glycerin; after this treatment it will usually be found that all symptoms of spasm have disappeared. The same result can sometimes be attained by nitrous oxid gas or the first stage of ether anesthesia.

Treatment of Organic Stricture.—After the diagnosis has been made and the caliber, resiliency, and irritability of the stricture have been determined and their number ascertained, the condition of the heart, kidneys, and bladder should be learned by making a clinical, bacteriologic, and microscopic examination of the urine.

Before any serious operation upon the urethra is performed, the quantity of urine secreted in twenty-four hours, as well as the amount of urea it contains, should be definitely ascertained. If the quantity eliminated is below the normal average and the urea is less than 1 per cent., no operative procedure upon the urethra should be undertaken, except in emergency cases.

General Considerations.—Urethral instrumentation should always be performed with the patient in the recumbent posture, with the shoulders slightly raised. The operator stands on the left of the patient and inserts bougies or catheters by grasping the penis, behind the corona, with the middle and ring fingers of the left hand; this permits the index-finger and thumb to be utilized in retracting the prepuce and separating the lips of the meatus. The beak of the instrument is inserted into the urethral orifice, the shaft resting on the patient's left groin. The glans penis is next gently drawn upon the instrument, the beak being kept in contact with the floor of the urethra in order to prevent its being caught in the lacunæ magnæ. After this point has been passed the handle of the instrument is brought to the middle line of the body and slowly pushed into the urethra, the handle being raised at the same time until it is perpendicular to the axis of the body. The beak of the instrument is now beneath the pubic arch. The instrument should then be slightly raised,

in order to bring the point of the bougie in contact with the roof of the urethra, so as to prevent its being arrested by the bulbous expansion of the canal.

The instrument is now very gently made to slide onward, the end of the sound passing along the membranous and prostatic urethra; as it does so the handle of the instrument descends until it reaches a point between the patient's thighs. When a false passage is made, this is evidenced by the sensation immediately imparted to the hand—as if the end of the instrument had been suddenly grasped and tightly held, instead of being movable, as is the case when the instrument is advancing successfully through the obstruction. There is always more or less hemorrhage, and on examination it will be found that the beak of the instrument has deviated from the median line which marks the course of the urethra. If the deep urethra has been invaded, this can be determined by means of a digital examination of the rectum, which will disclose the fact that not only has the point of the instrument deviated from the median line, but that the overlying tissues, whether urethral or prostatic, are much thinner than they would be if the instrument had not been deflected from its normal course.

It is essential that the instruments, the urethra, and the hands of the operator should be sterile. The foreskin, preputial folds, and glans penis should be thoroughly washed with soap and water and then with a solution of mercury bichlorid, 1 : 5000. Unfortunately, antiseptic solutions cannot be employed in sufficient strength to render the urethra sterile; much, however, can be accomplished by irrigating the urethra with a solution of mercury bichlorid 1 : 20,000; this should be employed only in operative cases, for in those patients who catheterize themselves, its daily use would tend to set up a urethritis. In chronic urethritis associated with stricture potassium permanganate solution, in strengths ranging from 1: 5000 to 1: 2000, or silver nitrate solution, 1: 15,000, is generally employed. When frequent instrumentation is necessary, one of the most satisfactory cleansing washes is a warm sterilized solution of boric acid. If there is no infection of the urethra, a sterilized normal salt solution may be employed.

The selection of the proper lubricant is a very important feature of the treatment. I have found liquid cosmolin to be most satisfactory. It can easily be rendered sterile by placing the jar containing it in a sterilizer for a few minutes before use. It should be kept in a wide-mouthed, tightly corked jar.

Beck suggests the use of a *prophylactic injection*, consisting of a 5 per cent. emulsion of iodoform in glycerin, before attempting instrumentation.

All instruments should be passed slowly and gently, avoiding force. If instrumentation gives rise to severe pain, persistent efforts to pass the instruments without the aid of an anesthetic result in more harm than good.

As soon as the patient has convalesced from an operation for stricture a small metal bougie that will pass through the urethra without causing

pain and hemorrhage should be inserted at least twice a week. Instruments of gradually increasing size are to be inserted, until one can be readily passed that corresponds in caliber to the full normal dilatability of the urethra. When this point is reached, the patient should be instructed in the use of the bougie, which should be inserted twice a week for at least six months, after which it may be employed once a week for about three months longer. If the urethra is then found to be smooth and pliable, and no evidence of the coarctation is manifest, its use may be discontinued, unless there is reason to believe that a recontraction is taking place, when the instrument must again be passed.

In young, healthy subjects, beyond attention to sexual hygiene and the functions of the kidneys and bowels but little is required. In elderly and debilitated men, in alcoholics, in drug habitués, or in the presence of a diseased heart, kidneys, or bladder, all the knowledge and skill at the command of the physician will be required.

The extent to which a stricture should be dilated before treatment should be discontinued is an important factor. As the normal dilatability of the urethra varies in different individuals, no fixed standard can be used as a guide. The normal dilatability of the urethra can be approximately determined by ascertaining the circumference of the middle of the flaccid penis and comparing it with the scale given on p. 545.

To determine whether or not a stricture is cured, the treatment should be continued until the urethra has been stretched to at least one number beyond its normal dilatability. For example, if the normal caliber of a urethra that is strictured is 31 mm., the dilatation is continued until a No. 32 bougie can be easily passed, after which, if the introduction of a No. 31 bulbous bougie fails to detect any narrowing, bands, or roughness, and an endoscopic examination shows the canal to be in good condition, local treatment is discontinued.

Meatotomy is frequently demanded for the relief of a mechanical impediment to micturition, or to facilitate the insertion of large instruments in performing urethral or vesical operations. The object to be accomplished in performing a meatotomy is merely to enlarge the opening sufficiently to permit the insertion of a urethral or a vesical instrument. When the orifice is too much contracted to permit of this, a very slight incision, not extensive enough to interfere with the physiologic function of the outlet, will frequently permit of sufficient dilatation to allow the introduction of the desired instrument. It is a good rule, when performing meatotomy, to make the opening too small rather than too large, for if the outlet has been made unnecessarily large, an annoying deformity difficult to remedy results.

The parts are sterilized in the usual manner. A pledget of cotton wrapped on an applicator is moistened with a 4 per cent. solution of cocain and inserted a distance of about one inch into the urethra, and allowed to remain in contact with the mucous membrane for five minutes. The penis is then steadied by grasping it between the middle and ring fingers of the left hand, leaving the thumb and index-finger free to retract the prepuce and separate the meatus. A curved bistoury is now inserted

into the urethra, behind the constriction of the meatus, and the point made to protrude at the skin surface, which, when the instrument is thrust through the structure and the overlying tissue cut through, will give an incision of the desired length. The cut must be made directly in the median line. The opening is then examined by means of a conical metal bougie or bougie à boule, to ascertain if the orifice is of sufficient size or if further bands remain to be severed. If the latter is the case, this may be accomplished by means of an incision made on the floor of the urethra, employing a probe-pointed tenotome for the purpose. Hemorrhage is controlled by packing the upper portion of the urethra with a small roll of absorbent cotton, wrapping the organ in several folds of gauze, and firmly applying a narrow finger bandage, the knot of which is so arranged that, when tied, it compresses the lips of the meatus and thus controls bleeding. The dressing is not disturbed until the patient desires to micturate; if the hemorrhage recurs, he should be directed to reapply the compress in the manner described.

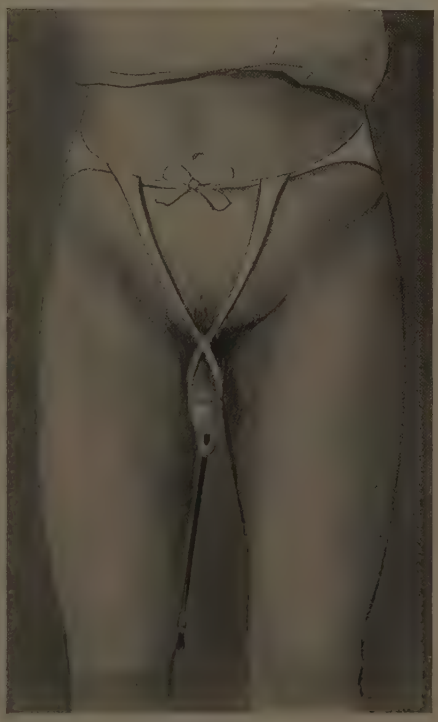

Fig. 290.—Intermittent Drainage, Continuous Catheterism.

Retention Catheters.—When a catheter or filiform bougie must be retained in the urethra for a considerable period of time, the following method may be employed to prevent it from slipping out of the canal. The instrument is inserted and fixed in place by means of a piece of tape so tied that the knot comes on the under surface of the penis; the two ends of the tape are carried around the middle of the body of the organ, and knotted once more on the dorsum; the ends are then carried up and fastened to a band about the waist, which is held in position by means of perineal straps (see Fig. 290).

Anesthesia.—I believe that the high mortality following operations for the relief of chronic urinary obstruction in patients advanced in years, with damaged kidneys, diseased heart, atheromatous degeneration of the cerebral vessels, and a history of one or more attacks of apoplexy, is due not so much to the operation itself, as to secondary shock, uremia, or suppression, the delayed effects of the anesthesia.

In cases of stricture within the first inch of the urethra the operation

can be done under local anesthesia, one dram of a 2 per cent. solution of cocain being injected into the urethra and retained in the canal for five minutes.

Operations upon the deep urethra should be performed under general anesthesia. If the kidneys are healthy, ether is preferable, but if they are diseased, chloroform should be administered. When the heart, arteries, and kidneys are diseased, I have frequently had very good results from spinal anesthesia, or a hypodermic injection of a combination of morphin and scopolamin.

In elderly and debilitated subjects and in complicated cases the patient should be instructed to drink large quantities of water for several days preceding the operation. The operation should be performed as rapidly as possible, and every precaution observed to protect the patients from cold and drafts. On being returned to bed, a submammary injection of 1000 c.c. of normal salt solution should be given.

When, as the result of instrumentation, a **false passage** has been made, the treatment consists in rest in bed, the administration of genito-urinary antiseptics, and continuous catheterism. If there is evidence of extravasation of urine or the formation of abscess, the tissues should be freely drained and a perineal urethrotomy performed.

Operation for Stricture.

Gradual Dilatation.—This is the method of choice in the treatment of the large majority of strictures, being readily carried out and attended with comparatively little danger. Theoretically, it is a perfect procedure, but, unfortunately, it is not applicable to every case. In soft recent strictures the number of permanent cures following gradual dilatation compares favorably with those resulting from internal urethrotomy, and, besides, is devoid of the risk attending the latter operation. Gradual dilatation may be employed for years with every advantage to the patient, no symptoms of obstruction manifesting themselves and no untoward effects arising from the prolonged use of the bougie.

Gradual dilatation is indicated in all cases of *recent dilatable stricture* in any portion of the urethra, and in those cases in which the stricture is not resilient, irritable, or nodular. Firm organized bands near the meatus or in the pendulous urethra are best treated by means of internal urethrotomy, for they are prone to be resistant and rapidly recontract after dilatation.

In the presence of diabetes, advanced disease of the kidneys, or heart disease, in the aged or debilitated, gradual dilatation is far safer than any other method of treatment. When chronic urinary fever coexists or fever follows urethral instrumentation, dilatation should not be attempted, external urethrotomy being the method of choice.

The instruments required are: Assorted sizes of conical steel bougies with the Thompson curve, ranging from No. 12 to No. 35 of the French scale; a dozen filiform bougies; Gouley's tunneled catheters, from No. 8 to No. 16, various sized Janet-Guyon or Le Fort dilators, and flexible bougies, with conical, bulbous, and oval tips.

In very tight strictures success will depend chiefly on the use of

properly constructed whalebone filiform bougies. Those usually sold are coarse, stiff, and practically worthless, therefore it is well for the surgeon to make a dozen of these instruments for his own use. Each whalebone should be thirteen inches long, and the diameter of its shaft should be small enough to permit it readily to slide through the opening in the end of a No. 2 Gouley catheter of the French scale. The lower two and three-quarter inches taper until it becomes absolutely capillary in fineness, terminating in an olivary tip.

Strictures of Large Caliber.—Both the urethra and the instruments to be used having been rendered aseptic, the operator inserts a conical steel bougie, one or two sizes smaller than the diameter of the coarctation, as there is usually associated with this condition more or less hyperesthesia of the urethra, and if an instrument large enough to fill or distend the stricture is used, severe pain is induced, which will cause more or less spasm and interfere with the progress of the bougie. The structures surrounding the seat of obstruction are generally congested, chronically inflamed, and softened; if there is much distention, the mucous membrane is easily lacerated, more or less hemorrhage results, and there is pain after micturition. Occasionally, as the result of the abrasion or laceration of the mucous membrane, urethral fever follows; by beginning with a bougie smaller in diameter than the caliber of the stricture, this complication is frequently avoided. As the pain of insertion diminishes and the amount of hemorrhage following lessens or ceases, a larger instrument is to be used. It should be introduced more frequently than every third day; at first it should be immediately withdrawn; later on, when the irritation caused by its insertion disappears, it may be allowed to remain *in situ* for from five to ten minutes, if its presence does not cause discomfort.

Filiform Strictures.—The successful passage of a filiform bougie through a tight stricture is dependent on the use of properly constructed instruments and on an accurate knowledge of how to use them. There are two varieties of filiform bougies on the market—the flexible French instrument and the old-fashioned whalebone bougie. The former is an excellent instrument, and safer than the latter in the hands of those not accustomed to urethral instrumentation. Unfortunately, their flexibility and caliber render them of little service in very tight tortuous strictures, through which a whalebone filiform can be passed with comparative ease. Brinton laid down a cardinal rule in these cases: "*Never attack with a filiform a stricture, especially a tight one, after the use, on the same day, of any catheter, bougie, or explorer.* The filiform should always be used *first*, as any other instrument, hard or soft, especially if of *larger size*, is apt to press or ram the aperture of the stricture or walls together. Its opening is thus distorted and rendered difficult of access; the stricture becomes for some time *impermeable to instrumentation*, although passable by urine."

The urethra is first examined, and the location and caliber of the stricture are determined; the patient is then directed to remain quiet, take a laxative, and five grains of quinin, together with one ounce of whisky, one hour before his next visit. When he returns he is preferably placed

on a narrow table, with the shoulders slightly elevated; the parts are sterilized in the usual manner. Irrigation of the urethra should not be attempted, as it is likely to cause spasm and thus interfere with the intended instrumentation. One dram of a 2 per cent. solution of cocain is injected into the urethra and retained for five minutes, at the end of which time it is permitted to escape and a half dram of a 5 per cent. emulsion of iodoform in glycerin is injected; this serves not only as a prophylactic measure against the development of urethral fever, but is an excellent lubricant as well. The penis is now grasped with the left hand, behind the glans, and a filiform inserted into the urethra and passed along the floor of the canal until the obstruction is encountered, when its progress will probably be arrested. It should then be gently rotated between the thumb and finger; *no effort or force must be employed* to make it pass onward, but another filiform should be passed alongside of the first one and the same gentle manipulation made. If this fails to find the aperture, the process should be repeated until six or eight whalebones have been inserted; then each one in turn should be rotated slightly. Should the effort to pass the instruments prove unavailing, it is wise to allow the patient to rest for a moment, leaving the filiforms *in situ*. Then, manipulating each in turn again, frequently one will be found that will traverse the contracted portion of the urethra and enter the bladder. When the operation is successful, the surgeon will be surprised at the ease with which the instrument is passed through the stricture once the aperture is found. If the opening cannot be detected, two or three filiforms should be withdrawn and then reinserted, working on the other side of the patient, when the whalebone will often enter the opening.

Brinton believes that the "hand instinctively works toward itself and so directs the filiform. Thus it happens if the stricture opening is eccentric, the bougie may travel away rather than toward the opening sought." If, after a fair effort, the instrument fails to pass, or if the patient becomes exhausted or restless or there is a slight but steady urethral hemorrhage, all attempts at instrumentation should be discontinued for at least twenty-four hours. In the case of hemorrhage the blood may clot and form a sticky mass that blocks the opening of the stricture and renders instrumentation, for the time, impossible. Gentle manipulation, carried out in the manner indicated, will eventually, in the large majority of cases, result in the successful passage of the instrument, after which an effort should be made to pass the smallest sized Gouley tunneled catheter over the filiform, which latter serves as a guide; if this succeeds, the instrument should be withdrawn and the next larger size introduced; this is all that should be attempted at the first treatment. The patient should then be put at rest for twenty-four hours, and two days later the filiform should be reinserted and a larger-sized tunneled catheter passed, increasing the size as the pain, irritation, or hemorrhage caused by the instrumentation subsides. Thus the stricture is gradually dilated until about a 16 mm. opening is made, after which the dilatation may be continued with rubber bougies inserted every third day until a No. 24 can be passed, when the cure may be completed by using metal instruments, in the

manner described under the treatment of strictures of large caliber. It will often be found that a filiform stricture will resist all efforts at dilatation until its caliber has been brought to about 18 mm., after which it will suddenly yield, making further instrumentation easy. If the orifice of the stricture cannot be found by the filiform, instrumentation may be facilitated by introducing the endoscope down to the seat of obstruction, and passing the filiform by means of direct vision.

When efforts to pass either the whalebone or the whip filiform have been unsuccessful, but it is found that the point of the instrument has become engaged in the stricture, a simple expedient that is occasionally successful is to leave the instrument in the grasp of the coarctation, when, on making another attempt, a few hours later, it will often be found that the bougie can readily be passed. Dilatation of this form of stricture is readily accomplished if the caliber is such that the smallest size of the whip bougie or the dilators of either Janet-Guyon or LeFort can be passed; when this can be done, by screwing on the follower and passing it through the stricture, then withdrawing it, and following with bougies two or three numbers larger, the coarctation can be sufficiently dilated to permit the remainder of the treatment to be carried out with the ordinary metal instruments.

In filiform strictures in which instrumentation causes constant hemorrhage, irritation, frequency of urination, or prostatic spasm, gradual dilatation should not be attempted; this is true also of those cases in which it is found impossible to insert the filiform bougie, or if the whalebone guide has been passed and a tunneled catheter or a dilator cannot be successfully passed over it through the constriction.

Continuous Dilatation.—This is employed for the relief of strictures of filiform caliber, situated in the bulbous or membranous portion of the urethra. It is applicable in two conditions: (1) That in which a stricture of small caliber is situated near the bulbomembranous junction of the canal, is associated with retention of urine, and is not amenable to gradual dilatation; (2) that in which the caliber of the stricture will permit only a filiform to be passed, the patient being, however, able to micturate with sufficient ease to permit him to be prepared for a radical operation. When the character of the stricture is such that only a whalebone or a "whip bougie" can be passed through the contracted portion of the canal, the instrument should be allowed to remain in the urethra for from three to four days, when it will be found that the dilating and relaxing effect of the continuous dilatation resulting from the presence of the bougie will be sufficient in most cases not only to facilitate, but to permit, the passage of some one of the various forms of urethral dilators, such as the Gouley tunneled catheter or the Janet-Guyon, Le Fort, or Thompson instruments. Continuous dilatation used in conjunction with more radical measures is of great value, so preparing the canal that the stricture can afterward be treated as the surgeon may deem most expedient. When continuous dilatation is suspended, further treatment by gradual dilatation is to be carried out; if this is found to be impracticable, modified rapid dilatation is the next

choice of methods. If an internal urethrotomy is required and the stricture must be divided from before backward, the stretching that the contraction has undergone will readily permit the use of such instruments as the urethrotome of Maisonneuve or of Treevan. Moreover, should it be necessary to perform a perineal urethrotomy in conjunction with other work required within the canal, the preceding dilatation of the stricture greatly simplifies this procedure, as a grooved staff can readily be introduced and the membranous urethra opened by means of a guide, in place of the more difficult maneuver of attempting this operation without one.

Filiforms should be passed in the manner already described when discussing the treatment of this form of stricture by gradual dilatation (p. 553). After the instrument is inserted, it should be fastened so that it cannot slip out of the urethra, the urine being passed either in drops or in a small stream running alongside of the bougie. When the case is complicated by retention, the filiform having been passed, an attempt should be made to thread a Gouley tunneled catheter over the whalebone; this is passed through the obstruction and the urine withdrawn, after which the bladder should be irrigated with a sterilized warm boric-acid solution, a small quantity being allowed to remain in the viscus. The catheter should then be withdrawn, *being careful to leave the filiform in place in the urethra;* if it becomes necessary, in the course of a few hours, the catheter may easily be replaced. If it is found impossible to guide any instrument for withdrawing the urine along the filiform and the symptoms of retention are not urgent, the whalebone should be left in the urethra, and the patient given a hot lemonade, a hot bath, ten grains of quinin and one-fourth of a grain of morphin, and a hot flaxseed poultice applied over the lower abdomen; he should then be wrapped in blankets and allowed to perspire freely. In a short time it will usually be found that the distended bladder will gradually be emptied by constant dribbling of the urine along the side of the bougie, and an attempt to pass a tunneled catheter a few hours later will usually be successful. *When the symptoms are urgent, the bladder having been distended for a long period of time,* the organ should be aspirated and free perspiration induced. If, in the course of a few hours, the urine reaccumulates in the bladder and catheterism is still found to be impossible, a perineal urethrotomy should be performed without further delay, using the filiform bougie for a guide, and the staff designed for this purpose. After the membranous urethra has been opened and the bladder drained, the normal caliber of the urethra should be re-established by appropriate measures (p. 498) and a catheter inserted.

Modified Rapid Dilatation.—The bulbomembranous junction is the commonest site for the formation of annoying filiform strictures. For the relief of this condition the operation that has given the most satisfaction in my hands is modified rapid dilatation. Brinton says that the success of the operation is due largely to "the intelligent use of *rightly constructed capillary whalebone bougies, which possess qualities not to be found in the gum or soft instruments, no matter how minute.*" The

proper method of passing a tunneled instrument along a filiform as a guide is also an *essential feature of a successful operation;* and it is the want of a proper understanding of the technic of this part of the operation that has resulted in many failures. In my experience a deep impermeable stricture is very rarely seen, and with skill and patience a filiform may usually be made to pass through almost any coarctation, no matter how small or devious its course; after which a successful termination may be brought about by either gradual or modified rapid dilatation. Of these, the former is the method of choice, but if it is found impossible to employ this, a modified rapid dilatation may be accomplished with the least loss of time and a minimum amount of suffering and risk to life, and with as permanent and satisfactory results as can be obtained by any other method. In 800 cases treated by this method failure or loss of life did not follow in a single instance, and the tendency for recontraction to take place was no greater than in those cases treated by cutting operations. Strictures subjected to modified rapid dilatation are stretched and not lacerated, as is shown by the small amount of hemorrhage that attends the operation. A urethroscopic examination made a few days later will disclose the fact that the urethral walls are smooth, and not ragged, as would be the case if laceration had occurred. The opponents of this operation claim that the method cuts and lacerates the stricture, whereas the wound made by a urethrotome is a clean incision. This statement is disproved by the fact that by a modified rapid dilatation the stretching is done gradually, slowly, and gently; the strictured tissues give way first, and the traumatism is limited to the constricting bands; on the contrary, the incision made by the urethrotome is not limited, and both diseased and healthy tissues are severed, resulting often in alarming, and in some instances even fatal, hemorrhage, with the attendant increased danger of sepsis. In the hands of skilful urethrotomists the mortality has been placed at between 4 and 6 per cent.; while I believe this to be too high, nevertheless it cannot compare favorably with a method that accomplishes the same results with practically no mortality.

Modified rapid dilatation is applicable to the treatment of strictures in the region of the bulbous and membranous portions of the urethra which are not resilient, irritable, or nodular. It should not be performed in those suffering from urinary fistula, abscess of the prostate or perineum, or in those cases where urethral instrumentation is always attended by urethral fever. It may be performed primarily to facilitate the introduction of a urethrotome or the passage of a grooved staff, so that a required perineal urethrotomy may be performed by means of a guide.

Instruments and Preparations for Operation.—The necessary instruments are a set of metallic sounds; filiform bougies; half a dozen Gouley tunneled catheters of assorted sizes; a soft-rubber and two flexible silk catheters, one of which should terminate in an oval tip and the other in a "rat-tail" extremity; an irrigating bottle large enough to hold a pint of fluid; a glass syringe with a capacity of four ounces; a wire stilet to render the soft-rubber catheter firm; a Thompson and a Gross dilator. The Thompson dilator is 7 mm. thick at its beak and 11 mm. at the thickest

portion of its shaft, and can be dilated to 22 mm. The Gross instrument is 14 mm. thick at the beak and 18 mm. at the upper portion of the shaft, and when the blades are fully separated, will dilate to 36 mm. There should also be on hand six ounces of a 5 per cent. emulsion of iodoform in glycerin; a mercury bichlorid solution, 1 : 1000 (for local use on external genitals); a quantity of warm sterilized boric-acid solution; sterilized gauze, sponges, and tapes to fasten the catheter in place after the operation.

Operation.—Four days before the operation a meatotomy, if necessary, should be performed, after which a filiform bougie should be inserted into the urethra as far as the neck of the bladder, and fastened so that it will not slip out; the patient should then be put to bed. The instrument makes continuous dilatation, the urine passing alongside of the

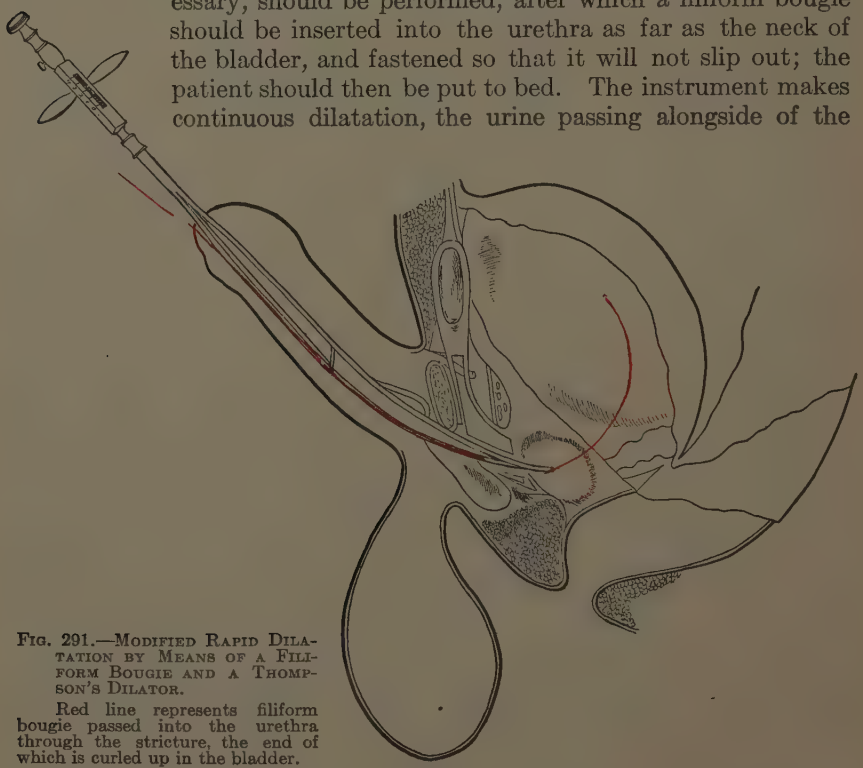

FIG. 291.—MODIFIED RAPID DILATATION BY MEANS OF A FILIFORM BOUGIE AND A THOMPSON'S DILATOR.

Red line represents filiform bougie passed into the urethra through the stricture, the end of which is curled up in the bladder.

whalebone. If, at the end of the third day, it is found that the quantity of urine secreted in twenty-four hours is normal and the amount of urea is not below 1 per cent., it is safe to proceed with the operation.

Some hours before the operation a rectal enema of magnesium sulphate, glycerin, soapsuds, and a pint of warm water is administered, and one hour before the patient comes to the operating table he is given a hypodermic of one-fourth grain of morphin and one-twentieth grain of strychnin.

After administering the ether the anterior urethra is gently irrigated with a solution of mercury bichlorid 1 : 20,000, and two drams of the iodoform emulsion is injected into the urethra. The end of the filiform protruding from the urethra is now threaded through the tunnel of the

Thompson dilator, which is passed very gently along the whalebone, which acts as a guide, until the obstruction is reached. The dilator should not be forcibly thrust onward, but its progress facilitated by making slight traction on the filiform and at the same time gently sliding the instrument downward and onward until its further advancement is arrested by coming in contact with the face of the stricture, *when all attempts to push or slide the dilator further should be desisted from.* If this rule is not observed, there is always danger of breaking the filiform, especially if it is bent by passing through a coarctation with an eccentric aperture. As soon as the beak of the dilator comes in contact with the stricture, the filiform should be slightly withdrawn and both the bougie and the dilator grasped, so that their lengths will be closely approximated, and then moved forward together by the same motion of the hand; it will then be found that the dilator will be guided by the lower extremity of the whalebone and will readily advance, passing through the constricted portion of the canal until the neck of the bladder is reached, as the handle of the instrument is made slowly to descend downward between the thighs. If the instrument has passed successfully through the stricture, it will be found to be freely movable, and urine will frequently escape alongside of the shaft. It now remains to stretch the stricture, which is accomplished by dilating it in three different portions—the posterior, middle, and anterior—by slowly turning the thumb-screw on the handle of the instrument. The dilatation should be performed gradually, by alternately lessening and increasing the screw power until the desired dilatation is produced. After the posterior segment of the coarctation has been dilated, the tension is lessened two millimeters, the blades are slightly withdrawn, and the middle and anterior segments of the stricture are treated in the same manner, so that the entire contracted portion of the canal has been dilated up to the full capacity of the Thompson dilator. Both the filiform and the dilator are now withdrawn, the Gross instrument inserted, and the operation proceeded with in exactly the same manner as when using the Thompson dilator, being careful to see that the caliber of the urethra is restored to its full normal dilatability before the instrument is removed. In order to determine that the stricture has been fully dilated and that future instrumentation will be rendered easy, a full-sized metallic bougie should be passed. If it is found that the operation has been successful, a soft-rubber catheter should be passed through the urethra and fastened in place. The introduction of this instrument will be facilitated by inserting in it a wire stilet, which is withdrawn when the neck of the bladder is reached. As soon as the urine has escaped, the bladder should be irrigated with a boric-acid solution and two drams of the iodoform emulsion injected into the organ. The catheter should not be removed until the fourth day, after which a conical steel bougie should be passed twice a week after the manner directed when considering the treatment of such conditions by gradual dilatation (p. 553). As a rule, no after-treatment is required beyond giving attention to the drainage and the bowels and performing irrigation of the bladder. The patient should be kept on a light diet until the catheter has been removed. If

such cases are examined months after this operation, as a rule no evidence of a pre-existing urethral obstruction can be found.

Divulsion.—This mode of treatment, while frequently mechanically successful, was attended with so many complications and so large a mortality that it has become obsolete.

Internal Urethrotomy.—This operation is indicated in strictures of either large or small caliber, situated in any portion of the urethra from the meatus down to the bulbomembranous junction, which are either *resilient* or *irritable*, and are, therefore, unsuitable for treatment by gradual dilatation. As the two forms of stricture just mentioned are of rare occurrence, internal urethrotomy is but seldom required. To this one exception may be noted: strictures within the first one and one-half inches of the canal are better treated by incision than by dilatation, as the latter causes pain and is likely to be followed by inflammatory reaction and rapid recontraction.

It is still a moot point whether a stricture should be incised on the floor or on the roof of the canal. A stricture of large caliber, situated anywhere from the meatus to the bulb, and requiring urethrotomy, should be divided on the floor of the canal. Strictures of small caliber are incised on the roof of the urethra, with the exception of those situated at the bulbomembranous junction or in the membranous portion of the urethra, when the incision is preferably made in the inferior wall of the canal, thus diminishing the danger of causing a severe or even a fatal hemorrhage as the result of wounding of the dorsal vein or the plexus of Santorini, an accident that has not rarely occurred when the constriction was divided on the roof.

Very resilient strictures, especially if traumatic in origin, belong to a class in which internal urethrotomy or any other method of treatment is frequently unsatisfactory. In such cases a urethrotomy may have to be repeated several times before a permanent result is attained, and even then recontraction is likely to take place. These cases require constant care and repeated dilatation throughout the patient's life.

In preparing the patient for any of the various forms of urethrotomy the field of operation, as well as the instruments, should be rendered sterile. As soon as the operation is completed the urethra is irrigated with a hot sterilized normal salt solution, which is usually sufficient to control the trifling hemorrhage that results from the incision. If the hemorrhage following division of stricture within the first two inches of the urethra is profuse, it may be controlled by packing the urethra with a roll of absorbent cotton that has been moistened with a 1 : 1000 adrenalin solution, and making compression on the wound in the urethra by applying a narrow bandage to the organ. In the course of a few hours the urethral compress should be removed and a soft-rubber catheter inserted and fastened in place. If the bleeding is due to division of a stricture situated further back in the penile urethra, one dram of adrenalin solution 1 : 2000 should be injected into the urethra and retained in the canal for five minutes, after which the rubber catheter should be introduced and the penis wrapped in gauze, firm pressure being made upon the urethra by

means of a narrow gauze bandage. When the blood comes from the deep urethra and cannot be controlled by the catheter and pressure, the flow may be temporarily checked by making digital compression of the perineum. Another method of arresting hemorrhage is to place a large compress on the perineum, put the arm-piece of a crutch on the compress, the ferrule being braced by the footboard of the bed, which should be elevated so that direct pressure will be brought to bear on the perineum. If the dorsal vein or plexus of Santorini has been wounded, no time should be lost, but an incision should be made at once in the perineum and the bleeding vessel secured. If this is found to be impracticable, the scrotum should be divided in the median line and the testicles separated and pushed one on each side of the incision, thus giving access to the urethra from in front of the bulb well down on the membranous urethra. The urethra should then be opened on the floor, and the bleeding point secured by either a ligature or a purse-string suture. After performing urethrotomy, except when the stricture is within the first inch of the urethra, continuous drainage should be maintained by means of the catheter for from one to four days, the length of time depending on the character, location, extent of the operation, and the amount of hemorrhage that followed the operation.

The *after-treatment* of these cases consists in curing the local lesions causing the chronic urethritis, and performing continuous dilatation by inserting a full-sized metal bougie twice a week for a period of months.

Internal Urethrotomy for Strictures of Large Caliber.—In strictures of this description the incision is made upon the *floor* of the canal *from behind forward*. When the operation is done for the relief of strictures of the meatus or of those situated in the navicular portion of the urethra, local anesthesia may be employed, one dram of a 2 per cent. solution of cocain being injected into the canal and allowed to remain for five minutes. The instruments required are a slightly curved, blunt-pointed tenotome, bulbous metal bougies, and a soft-rubber catheter.

Operation.—The knife is introduced into the urethra with the cutting-edge turned toward the floor of the canal. After the blade has been passed behind the obstruction for about one-fourth of an inch the incision is made directly in the median line, on the inferior wall, and should be of sufficient length and depth to divide all constricting bands, so that, after the operation, a bougie at least *two sizes larger* than the normal caliber of the patient's urethra can be readily introduced. This is done to allow for a certain amount of recontraction that inevitably occurs after the wound has healed. The meatus must be enlarged, if necessary. After the operation has been completed and the passage of a bulbous bougie shows that the canal is free from obstruction, it should be irrigated with hot normal salt solution and a soft-rubber catheter inserted and allowed to remain *in situ* for two days.

When the strictures are situated in the penile urethra, specially designed urethrotomes, such as the Gross or the dilating urethrotome of Otis, are necessary for the performance of urethrotomy. In operating

upon strictures of large caliber with these instruments the incision is made upon the floor of the canal from behind forward.

The *Gross* instrument is reserved for strictures that are either resilient or irritable, of comparatively recent origin, and not extensively organized, or where the constriction assumes the form of a band or a bridle. It can be employed only in those cases in which the coarctation will permit of a certain amount of dilatation, as the circumference at the bulb measures 23 mm. In performing internal urethrotomy with the aid of this instrument anesthesia may be induced by means of nitrous oxid gas. The urethrotome is introduced into the urethra and passed gently down until the obstruction is reached, when the bulbous extremity is insinuated through the contracted portion of the canal and carried onward until it has reached a point at least one-half inch beyond it. By means of the mechanism of the handle the knife is made to protrude from its sheath, and the incision is made on the floor of the urethra by pressing the blade firmly against the urethral tissue and drawing it forward until all sense of resistance is overcome, thus making a clean incision behind and then directly through the constricted portion of the urethra, to about the same distance in front of the obstruction. The urethra is now irrigated and the soft-rubber catheter passed, the latter being removed on the fourth day. The *Otis urethrotome* is employed in operating upon strictures situated in the anterior urethra that are resilient, irritable, nodular, or fibrous, well organized, and that involve the submucous structure. It is also used to complete the operation in strictures of small caliber in which the preliminary incision was made by a Maisonneuve urethrotome. As the caliber of the dilating urethrotome is 18 mm., the stricture must have this caliber before the instrument can be introduced; in such cases, therefore, a preliminary dilatation or incision of the obstruction with an instrument specially designed for cutting strictures of small caliber must first be made. The inventor of this instrument directed that after its introduction into the urethra the canal should be overdistended and the knife-blade drawn through the constricted portion of the canal, which thus severed deeply not only the fibrous structure that composed the coarctation, but healthy tissue as well. This technic resulted, in many instances, in the production of an incurvation of the penis, causing physical disability persisting for months or even throughout life. After an unsatisfactory experience I soon learned that if, after the instrument was in place, the blades were *separated just sufficiently to fill the constricted portion of the canal comfortably without causing overdistention*, so that the strictured portion was fixed and presented a firm, unyielding surface to the passage of the knife, the fibrous structure forming the coarctation would alone be divided and the patient would convalesce without the development of untoward consequences. I regard this instrument as one of the most satisfactory and reliable to use for the relief of cases of the kind under consideration. I believe, with Bryson, that since the "stricture disease" chiefly affects the floor, the inferior wall is the best site for the incision. When the stricture is cut on the roof, there is more danger of hemorrhage, which may be followed, later, by the development of incurvation of the penis.

It is essential, before operating, to ascertain the depth of the stricture from the meatus and the normal caliber of the patient's urethra; the latter should be determined by means of the urethrometer.

The dilating urethrotome is introduced into the urethra with the groove along which the knife-blade travels presenting toward the floor of the canal; it is carried down until it is passed slightly beyond the seat of obstruction. By means of the wheel connected with the handle the blades are separated until the constricted portion of the canal firmly grasps the dilated shaft of the instrument, *without causing overdistention.* The knife is then drawn directly along the median line, through the cicatricial mass, until it is completely severed. The blade is then returned to its sheath, and the instrument withdrawn. The urethra is next explored by means of a full-sized bougie à boule, and if any constricting bands are discovered, they should be incised in the same manner, after which the urethra should be irrigated and a full-sized soft-rubber catheter inserted.

Internal Urethrotomy for Strictures of Small Caliber.—Strictures in the penile urethra whose caliber is less than 15 mm. must first be dilated, by either continuous or gradual dilatation, before it is possible to insert the instrument for performing urethrotomy. When the obstruction can be permeated only by a filiform bougie, internal urethrotomy may be successfully performed by means of a knife designed by me for the purpose. The instrument consists of a staff, ten inches long, having a handle at one end and terminating in a triangular blade at the other, the apex of the blade being blunt. On the under surface of the shaft that carries the knife is a ring through which a filiform may be threaded, serving to guide the instrument in its passage along the urethra. In performing this operation the penis must be steadied during the progress of the knife along the canal by putting the organ on the stretch. The filiform is now threaded through the ring at the end of the instrument, and passed along the whalebone into the urethra, with the blade presenting toward the inferior wall, until the obstruction is reached, when, by gradual but firm pressure, the knife is made to incise the cicatricial mass from before backward directly in the median line. The division of the coarctation permits the introduction of a Thompson dilator, and the caliber is further increased up to 18 mm., after which the instrument is removed and the urethrotome of Gross or of Otis is employed to divide the remaining constricting bands, thus restoring the canal to its normal caliber.

Urethrotomy in Impermeable Stricture of the Anterior Urethra.—Occasionally cases are encountered in which the urethra is either partially or completely occluded from the meatus down to the bulb. Such cases are often complicated by coincident penile urethral fistulas. For the relief of this form of obstruction I have employed the following method of operating with the most gratifying results: The penis is held firmly by being stretched upward toward the pubic bone. A narrow bistoury, four inches long, is then inserted into the meatus and carried steadily downward and onward through the cicatricial tissue along the course of the urethra until the end of the obstruction is reached. The incision along the almost obliterated urethral tract cuts a groove in the course of the

canal, which is usually attended by trifling hemorrhage and permits the passage of the Thompson dilator, by means of which the canal can be stretched sufficiently to allow the Otis urethrotome to be employed, dilating and cutting until the normal caliber of the canal is restored; after this a grooved urethral staff is passed and external perineal urethrotomy performed by means of a guide. The sinus in the penis is opened, cureted, and a full-sized soft-rubber catheter is passed through the urethra to the bladder and fastened in place. Continuous drainage is maintained for at least four weeks. The perineal wound is packed lightly with iodoform gauze, which is removed on the second day and not replaced. The results obtained by this method of treatment in apparently hopeless cases have been almost phenomenal.

Internal Urethrotomy for Strictures of Small Caliber in the Deep Urethra.—Different forms of urethrotomes, all embodying the same principles, have been devised for the purpose of severing, from before backward, tight strictures in the region of the bulbous or membranous portion of the urethra. Of these, the Maisonneuve and Treevan instruments are most used. With the former the incision is made on the roof, and with the latter, on the floor, of the canal. Before such instruments can be introduced the caliber of the stricture must be dilated to 9 mm.; if this can be accomplished, in an ordinary stricture, internal urethrotomy will be unnecessary, for such cases can be relieved more satisfactorily by either gradual or modified rapid dilatation. When a deep-seated stricture is resilient or irritable, the only method of treatment consists in performing urethrotomy. In such cases I have abandoned the use of the aforenamed instruments, for this method of operating, even in the most skilful hands, is attended by a mortality of 4 per cent. The complications most often observed are extravasation or suppression of urine, uremia, urinary fever, and, not rarely, fatal hemorrhage from wounding of the dorsal vein, the plexus of Santorini, or the artery of the bulb. The method of Maisonneuve has been modified, and has been found more satisfactory than the original technic. If the stricture is filiform in caliber but capable of being stretched, continuous dilatation by means of a whalebone bougie is first performed, the instrument being allowed to remain in the urethra for three days; after this modified rapid dilatation is performed, so as to permit the introduction of a grooved urethral staff, and an external perineal urethrotomy is done by means of a guide. Any remaining obstruction is now incised on the floor of the canal by means of the Otis urethrotome, being careful not to *overdistend the urethra while making the incision, thus avoiding incising anything but the cicatricial tissue.* The final steps of the operation consist in irrigating the urethra and introducing a full-sized rubber catheter, which is allowed to remain *in situ* until the opening in the membranous urethra has closed. Continuous drainage prevents urinary fever, relaxes muscular spasm, places the parts at physiologic rest, causing atrophy and absorption of the strictured tissue, and assures healing without the danger of ensuing perineal fistula. The catheter should be removed about every three days and a clean instrument reintroduced. If continuous catheterism is employed,

it is not necessary to insert a metallic bougie until the wound in the perineal portion of the urethra has healed.

Internal and External Urethrotomy Combined.—Reginald Harrison first performed this operation for the relief of traumatic or organic strictures that were resilient, irritable, nodular, or associated with urethral fistulas. It is also reserved for those cases in which the coarctation is permeable only by a filiform bougie. Clinical experience has shown that dilatation, incision, and perineal drainage, by putting the urethra at physiologic rest, not only prevent the subsequent development of urethral fever, but cause a fatty degeneration, atrophy, and absorption of the cicatricial tissue to take place, resulting in permanent benefit, the walls of the urethra becoming soft and pliable. When the stricture is dilatable, the operation is done by first effecting either gradual or modified rapid dilatation, after which an external perineal urethrotomy is performed, any remaining obstructing bands in the urethra being then severed by means of the Otis urethrotome.

The operation for the relief of strictures permeable only by a filiform will be considered under the head of External Urethrotomy by Means of a Guide (p. 567).

External Perineal Urethrotomy.—This operation is performed either with or without the aid of a guide in the urethra. When done with the guide, the operation is a comparatively easy one. In cases of traumatic impermeable strictures, or of rupture of the urethra with extravasation of urine or blood, the normal relation of the tissues of the perineum being distorted, this operation, when done without a guide, may become one of extreme difficulty. To insure success, a good light, perseverance, and a thorough practical knowledge of the anatomy of the perineum are essential.

Perineal urethrotomy is done for the relief of non-dilatable, irritable, resilient strictures of small caliber, associated with urinary fistula or abscess of the perineum. It is also performed in impermeable strictures, either with or without retention of urine, in rupture of the urethra, and is also done in conjunction with an internal urethrotomy performed on some other portion of the canal.

Technic.—The patient should be placed in the lithotomy position, the buttocks projecting slightly beyond the edge of the table, and elevated by means of a sand-pillow; the legs are flexed on the thighs and the thighs on the abdomen, being held in this position by assistants. The perineum will now be on the same plane as the eye of the operator when seated opposite the patient, allowing him to look down into the perineal wound and observe every step of the operation. The hemorrhage following perineal section is not, as a rule, severe; if, however, it is profuse, its origin is generally in the region of the bulb, coming from the incised ends of the urethra or from the plexus of veins in the vicinity of the prostate. It can usually readily be controlled by packing the wound firmly with iodoform gauze, which is carried along the side of the catheter up to the neck of the bladder. When this is not effective, and the application of a ligature is difficult, the wound should be separated by means of retractors and the

bleeding vessels seized by hemostatic forceps, which should be allowed to remain for three or four days. If the hemorrhage comes from the bulbous portion of the canal, this should be exposed by free incision and the bleeding vessels controlled by either ligature or purse-string suture.

The question of drainage after a perineal urethrotomy is one of great importance. In such cases it is best to resort at once to continuous catheterism. A full-sized soft-rubber catheter is passed and allowed to remain in the urethra until the new canal has formed about it. The effect of the continuous pressure exerted on the inflamed and congested urethra is most beneficial. Tenesmus is relieved, the bladder is put at rest, and urinary fever is prevented. Convalescence is assured without the formation of a perineal urethral fistula. In cases in which combined internal

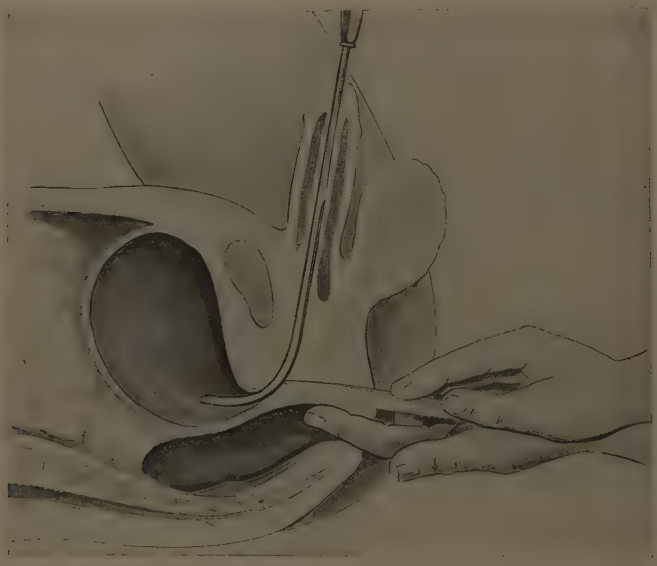

FIG. 292.—EXTERNAL URETHROTOMY.
The manner in which the knife is made to enter the groove of the staff through the lower perineum.

and external perineal urethrotomy has been performed and it is then found difficult to pass a catheter in the usual manner because of the rough and nodular condition of the urethra, the manipulation may easily be accomplished by inserting a pair of long forceps, designed for removing foreign bodies from the urethra, through the meatus and making the jaws of the instrument appear at the perineal wound (Fig. 293). The proximal end of the catheter is then caught and drawn from behind forward until it protrudes an inch or so beyond the meatus. The vesical end is then passed along a probe-pointed gorget, through the membranous and along the prostatic portion of the urethra into the bladder.

When infiltration of urine into the perineum has occurred, or when a perineal abscess or sinus or a large amount of nodular tissue due to chronic inflammation is present, no effort should be made to close the perineal

wound; if none of these conditions exists, the wound should be approximated by means of interrupted silkworm-gut sutures, leaving a small opening at the lower angle for the protrusion of the gauze packing, which should be removed on the second day and not replaced. The packing of a perineal wound for prolonged periods after operation is undoubtedly a frequent cause of delay in healing, the result of the formation of a fistulous

FIG. 293.—METHOD OF PASSING THE CATHETER FROM BEHIND FORWARD, BY MEANS OF URETHRAL FORCEPS, FOR CONTINUOUS DRAINAGE AFTER HAVING PERFORMED EXTERNAL PERINEAL URETHROTOMY.

opening. The end of the catheter protruding from the meatus is connected with a rubber tube leading to a vessel under the bed, into which the urine drains from the bladder, the patient being thus kept dry and clean (Fig. 294).

External Perineal Urethrotomy with a Guide.—In this operation the membranous urethra is opened with the aid of an instrument that serves to guide the surgeon by rendering the deep urethra easy of recog-

nition by means of an incision in the perineum. Various instruments are employed for this purpose, among them being the Syme's staff, the grooved urethral staff, the Gouley tunneled catheter, the Thompson dilator, and the whip or whalebone bougie used in conjunction with Horwitz's dilating perineal staff. In addition to the guide there are required a scalpel, scissors, hemostatic forceps, Wheelhouse probe, Teale probe-pointed gorget, perineal retractors, a soft-rubber catheter, and an Otis urethrotome. The Syme's staff is the guide usually employed, but I have found this instrument unsatisfactory for the reason that the narrowed terminal third of the shaft, which is intended to pass through the contracted portion of the urethra, may, in a deep perineum, be difficult to locate and thus render fixation of the urethra so that it may be incised troublesome; moreover, the channel is so shallow and narrow that it is often impossible to keep the point of the knife in the groove, and, as a result, the blade is constantly slipping from the guide before the incision is completed.

Fig. 294.—Continuous Catheterism in the Recumbent Posture.

In order to employ the Syme's staff it is necessary that the stricture should have a caliber of six millimeters; if this is the case, it is much quicker, more satisfactory, and easier first to stretch the stricture by means of modified rapid dilatation, and then either to employ the Thompson instrument as the guide or to make use of the full-sized grooved urethral staff. The technic of an external perineal urethrotomy performed by means of the Syme's staff, the Thompson dilator, or the grooved urethral staff is practically the same in each instance.

External Perineal Urethrotomy, Using the Thompson Dilator as a Guide.—Ether is administered, a filiform bougie is inserted, and the Thompson dilator threaded over it and passed into the urethra as far as the neck of the bladder. Modified rapid dilatation is then performed, and the blades of the instrument left separated just sufficiently comfortably

to distend the urethral walls and hold the canal firm and steady. An assistant holds the staff up against the abdomen, in the median line, and hooks it up against the pubic bone. The patient is placed in the lithotomy position. The scrotum is drawn up out of the way, and the instrument so held that it can readily be felt in the membranous urethra by palpation of the perineum. An incision is now made along the median raphé, from the attachment of the scrotum down to the region of the sphincter ani, dividing the skin and superficial and deep perineal fascia, exposing the accelerator urinæ muscle at the bottom of the wound; the tendinous raphé is next divided, bringing the urethra into view, which is thus fixed and distended by the aid of the dilator. A tenaculum is then passed on each side of the staff into the urethra, and placed in the hands of the assistants who are holding the legs, directing them to make gentle traction, which brings the urethra prominently into the wound, where it can readily be incised, the guide being exposed *in situ*. The edges of the incised urethra should then be seized with hemostatic forceps, which are handed to an assistant, and the tenaculum removed. The Wheelhouse probe is next introduced through the membranous and prostatic urethra until the neck of the bladder is reached: this instrument serves to guide the Teale gorget through the perineal wound down to the neck of the bladder; as soon as this is accomplished, the Wheelhouse probe and dilator are removed. Any remaining constricting bands, caused by the stricture, are incised and dilated by means of the Otis urethrotome; a soft-rubber catheter is inserted from the meatus into the bladder, and left in place until the continuity of the deep urethra has been restored. Bleeding is controlled by packing the perineal wound with iodoform gauze alongside the catheter, using the gorget as a means of guiding the gauze down to the neck of the bladder. The gauze should be allowed to remain for forty-eight hours, and then removed and not replaced. The perineal wound is closed by means of interrupted silkworm-gut sutures, leaving a small opening at the lower angle for the protrusion of the packing.

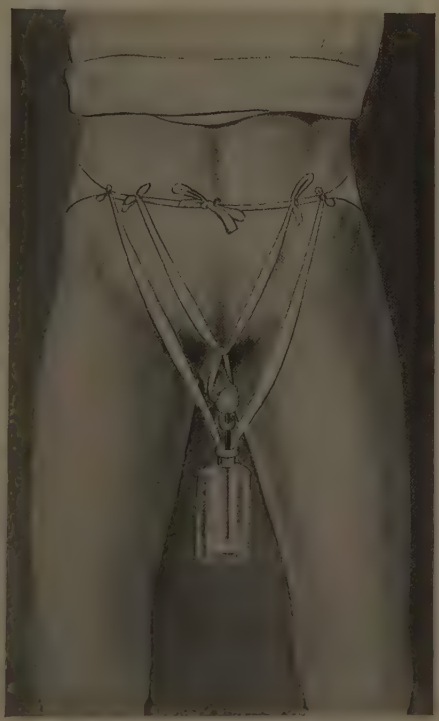

FIG. 295.—CONTINUOUS DRAINAGE.
The patient is allowed to be up and to walk about.

Perineal Puncture of the Membranous Urethra (Buttonhole Operation).—This method of performing perineal urethrotomy is sometimes employed when it is desired to drain the bladder after an internal urethrotomy has been performed. A grooved urethral staff is passed, the patient is placed in the lithotomy position, and a long straight bistoury, with a narrow blade, is inserted one inch in front of the anus, its back being turned *toward the rectum;* the instrument is carried steadily inward in the median line until it reaches the groove in the staff inserted into the urethra, thus puncturing the membranous urethra; as the knife is removed the incision is slightly enlarged upward, to make it of sufficient length to admit the index-finger. If the mucous membrane of the canal has not been completely divided, the tip of the finger is held against the staff and a probe-pointed bistoury is inserted alongside the finger as a guide until the staff is reached, when the undivided tissue between the finger and the staff is incised. The Wheelhouse probe is now passed into the perineal puncture along the groove in the staff until the neck of the bladder is reached; this serves to guide the passage of the Teale gorget, after which the urethral staff and probe are removed and a drainage-tube is passed along the Teale gorget and fastened in place.

Fig. 296.—Horwitz's Method of External Perineal Urethrotomy with Filiform Guide.

External Urethrotomy for Stricture Permeable Only by a Filiform.—This operation has been greatly simplified by the use of a perineal staff devised by me; it may be employed with either a whip or a whalebone filiform bougie. It will be seen from the illustration (Fig. 296) that the instrument consists of two blades in close approximation, which, together, form a smooth staff having a thumb-screw at one end, by means

of which the blades may readily be separated. It works on the same principle as the Otis dilating urethrotome. The distal end of the staff terminates in a rounded nut, which can be removed and replaced by a whip filiform, as shown in Fig. 296. An opening in the nut at the end of the staff will be observed, which leads into a tunnel through which an ordinary whalebone filiform can be passed. The filiform is employed when it is found impossible to insinuate the whip bougie.

When the whip bougie can be passed through the stricture, it is fastened to the perineal staff in the manner shown in Fig. 296. The blades of the instrument are closed and the staff is passed into the urethra until arrested by coming into contact with the shoulder of the stricture. The whip bougie being pushed in front of the staff, reaches the bladder and curls up, and when the urethra is opened, serves to guide the operator, as it is inserted directly through the structure. If the whip bougie cannot be passed through the stricture, a whalebone filiform is inserted. The tunnel end of the staff is threaded over the filiform, and introduced into the urethra until arrested at the contracted portion of the canal. By turning the thumb-screw the blades are separated. The amount of separation is noted on an indicator on the handle of the staff. When the blades are separated, the urethra in front of the stricture is not only fixed, but rendered prominent, and the operator, after making the incision through the skin, can readily open the urethra with precision and ease. The separation of the blades fixes the urethra and serves to hold it steady. When the staff is in position, with blades expanded, the location of the urethra can readily be detected by palpation over the tissue of the perineum. Whenever the whip bougie or filiform is employed in conjunction with the staff, the urethra can readily be detected, and when the latter is incised, the instrument will be found passing through the stricture, and can be traced without difficulty to the entrance of the bladder.

When the patient has been placed on the operating table, an effort should be made to introduce the whip bougie; if this fails, a filiform should be inserted, and the perineal staff threaded over this and passed down to the strictured portion of the urethra; the blades are then separated and given to an assistant to hold, who at the same time lifts the scrotum out of the way. The patient is then placed in the lithotomy position, the leg being flexed firmly on the thigh and the thigh on the abdomen. The buttocks should project slightly beyond the edge of the table, and be elevated by means of a sand-pillow, so that the perineum is on the same plane with the eye of the operator. A free incision is made through the skin, extending from just below the junction of the scrotum with the perineum to the anterior border of the sphincter. The superficial and the deep layer of fascia are next divided for the whole length of the incision, which exposes the accelerator urinæ muscle. This consists of two symmetric halves united along the middle line of the perineum by a tendinous raphé that serves to mark the exact location of the urethra. When the surgeon is about to penetrate the perineum, he must be careful not to carry the incision higher that the attachment of the central tendon, for

fear of wounding the bulb; in cutting downward he must guard against injuring the rectum. The space that he can work in with safety is a little over half an inch. The tendinous raphé of the muscles should now be divided, bringing the urethra into view; with the aid of the perineal staff the canal is fixed and distended. A tenaculum is then passed on each side of the staff and handed to an assistant, who is directed to make gentle traction, which brings the urethra prominently into the wound, where it can be incised, in front of the stricture, when the staff will be exposed in position.

The edges of the incised urethra are then grasped with hemostatic forceps and handed to an assistant, the tenaculum being removed. The upper angle of the wound in the urethra is likewise seized with forceps, which the surgeon holds in his left hand, making traction on three portions of the urethral incision, and pulling the strictured surface of the canal so that it presents directly in front of the operator. The Wheelhouse probe is then made to follow, through the stricture, the whalebone filiform or the whip bougie—whichever had been employed. As soon as the aperture of the stricture is located the probe is inserted by the side of the filiform, *parallel* to the perineal raphé, and carried along the contracted portion of the urethra until the point reaches the floor of the perineum, just above the rectum. The index-finger of the left hand inserted into the rectum serves as guide: the *probe is brought from the vertical to the horizontal position*, and made to pass directly through the prostatic urethra into the bladder. In some instances it will be found, after the instrument has been inserted into the upper portion of the membranous urethra, that it is impossible to make it describe the curve naturally assumed by this portion of the urethra; this difficulty can readily be overcome by inserting the index-finger of the left hand into the rectum, at the same time dissecting the tissues of the perineum, including the strictured portion of the floor of the urethra, directly down upon the probe; the handle of the instrument can then be readily depressed and carried into the bladder. When the probe has entered the bladder, it is handed to an assistant, who grasps it firmly. With the index-finger in the rectum, which serves to prevent injury to that canal, a probe-pointed bistoury is passed along the groove on the under surface of the probe, so as to divide the stricture throughout its entire length, after which the Teale gorget is passed beside the probe, until the point of the instrument enters the bladder. As evidence that this has been accomplished is the fact that urine will be seen to flow along the instrument. The probe is then removed, and a soft-rubber catheter passed through the penile urethra until the point of the instrument appears in the perineal opening, when it should be seized between the finger and thumb of the surgeon, pulled well into the incision, and made to pass along the gorget into the bladder. The wound should then be partially packed with iodoform gauze and closed with interrupted silkworm-gut sutures, leaving the lower angle open for drainage.

External Perineal Urethrotomy without a Guide.—This operation is indicated in any form of permeable stricture of the deep urethra, especially if it is associated with retention or extravasation of urine from

rupture, when the perineum is riddled with sinuses, or if nodular and brawny cicatricial tissue in the perineum is present. When operating by the perineal route, in strictures of this character, it is not sufficient to drain the bladder by means of a perineal cystotomy, but any existing obstruction in any other portion of the urethra, due to stricture, must likewise be removed and the canal restored to its normal caliber.

The instruments required are: A scalpel; a sharp and a probe-pointed bistoury with a narrow blade; a Wheelhouse probe; a Teale gorget; a Horwitz dilating perineal staff; Thompson's urethral forceps; Otis' urethrotome; perineal retractors; hemostatic forceps; two tenacula; dissecting forceps, and a soft-rubber catheter.

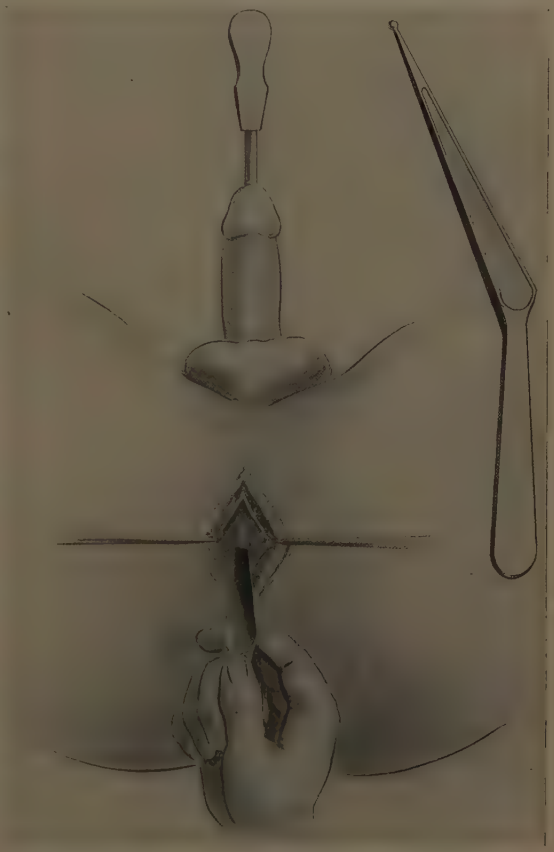

Fig. 297.—Wheelhouse's External Urethrotomy.

This procedure is a modification of that known as Wheelhouse's operation, the Horwitz perineal staff being substituted for the guide used in the original operation, and some radical changes being made in the technic, tending greatly to simplify the procedure by enabling the operator to locate the urethra with absolute certainty and without loss of time; by following the details of the further manipulation suggested the proximal portion of the canal can be found without difficulty and the continuity of the urethra easily re-established. This method is also applicable to cases of rupture of the urethra with extravasation of urine. The Horwitz dilating staff to be used as a substitute for the Wheelhouse instrument has been fully described on p. 571. The latter is a long, narrow staff with a shallow groove on the under surface and a slight hook on the end; when inserted, this instrument fails to render the urethra prominent or to hold it steady, so that in dissecting down upon the instrument it is frequently difficult, in a deep perineum, to locate the canal; hence when

an effort is made to incise the urethra, the mucous coat of the canal rolls away from the point of the knife, and the blade incises the tissue on each side of the guide without opening the urethra: moreover, when the canal is once opened, the small hook on the end fails to hold the upper edge of the incision and constantly slips away, so that the canal must again be sought for. Finally, the staff in the perineal wound is constantly in the operator's way, interfering with further manipulations. The Hor-

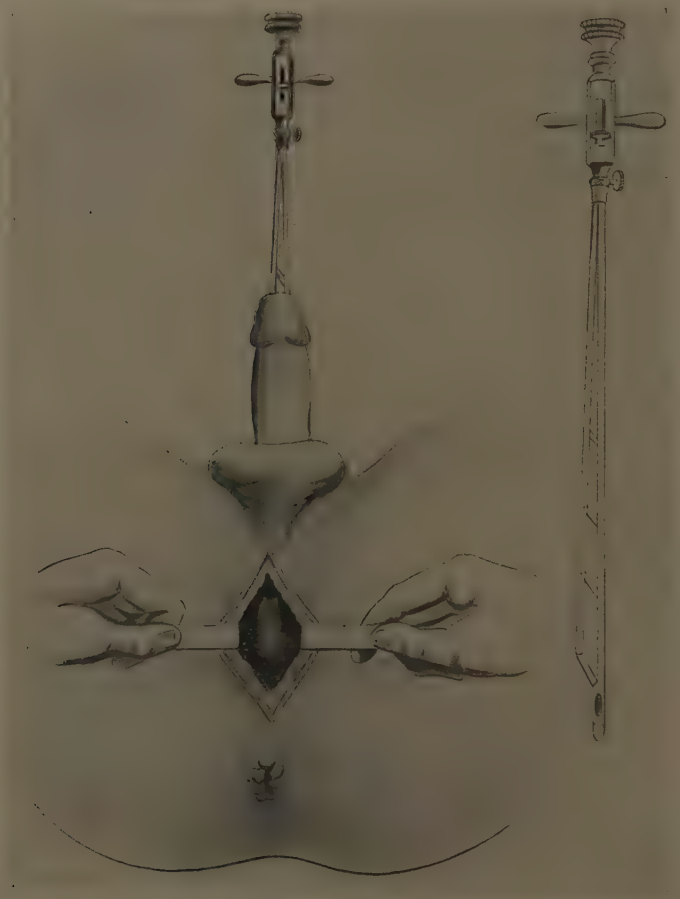

FIG 298.—EXTERNAL PERINEAL URETHROTOMY WITHOUT A GUIDE, EMPLOYING HORWITZ'S DILATING URETHRAL STAFF.

witz staff has the advantage not only of holding the urethra fixed, but of rendering it prominent in the perineum, so that the urethra can be incised with absolute precision, without loss of time, and without reference to the anatomic landmarks, this stage of the operation being performed automatically.

Horwitz Operation.—The method of opening the urethra will depend on whether the canal is occluded at the bulbomembranous junction or in the

membranous urethra. In the former case the urethra must be incised behind the stricture, whereas in the latter it must be opened in front. The perineal staff, with the blades closed, is passed into the urethra until the seat of obstruction is reached; the patient is then placed in the lithotomy position, and the staff intrusted to an assistant, who is instructed to hold the beak of the instrument firmly in contact with the face of the stricture, at the same time drawing the scrotum away from the perineum. The blades are now separated, and an incision is made in the median line of the perineum, from the junction of the scrotum down to the region of the sphincter ani; the cut divides the skin and superficial and deep fascia; these are drawn aside by means of retractors, when the accelerator muscle will be discovered at the bottom of the wound; the muscle is divided in turn along its tendinous raphé, which, when retracted, will expose the canal fixed and made prominent by means of the dilated guide. If the point of the staff has been arrested by the stricture at the bulb, the assistant is directed to push the staff downward and outward, so that the point of the instrument covered by the urethra is brought prominently into the perineal wound. An incision is now made directly through the urethral wall and the cicatricial tissue composing the stricture until the canal is opened, exposing the staff *in situ*, and completely dividing the coarctation. The blades are then closed slightly and the instrument pushed through the opening in the urethra and again separated. If more constricting bands are discovered, they may readily be divided, since the field of operation is visible. The Wheelhouse probe is now passed through the membranous and prostatic urethra until the bladder is reached; the Teale gorget is guided along the probe, which is then removed, leaving the gorget in place. The blades of the perineal staff are closed, and the instrument withdrawn from the urethra. Any further constriction that may exist in the penile urethra is incised and dilated with the Otis urethrotome, and a full-sized rubber catheter passed from the meatus down to the bladder and left *in situ*. When the beak of the instrument is arrested in the membranous urethra, the canal is exposed by the perineal incision and opened in front of the stricture, which is even a simpler procedure than opening the canal from before backward. As soon as the canal is opened the lateral walls and the upper angle are seized with hemostatic forceps, and by making traction on three different portions of the urethral wound, the strictured surface is pulled forward so that it presents directly in front of the operator. The aperture of the coarctation can usually be recognized or readily found by searching about with the Wheelhouse probe, which is insinuated through the constricted portion of the canal and passed along until the neck of the bladder is reached. The index-finger of the left hand is now inserted into the rectum. An assistant holds the probe steady, with the groove on the under surface, presenting toward the rectum; a probe-pointed bistoury is passed along the groove until the stricture is divided along its entire length. The Teale gorget is next passed alongside the probe until the point reaches the neck of the bladder. The probe is now removed, and the index-finger passed along the gorget in order to ascertain if all the constricting bands have been severed; if this

has not been done, the probe-pointed knife must be reinserted and the cicatricial tissue further divided. The operation is completed in the same manner as when the urethra is opened from behind forward (see p. 567).

Perineal Urethrotomy without a Guide for Traumatic Stricture and Rupture of the Urethra.—External perineal urethrotomy for the relief of these conditions is frequently one of the most difficult operations in surgery. When a traumatic stricture of the deep urethra is associated with the presence of sinuses and dense cicatricial tissue in the perineum, or if rupture of the urethra with extravasation of urine has taken place, it is often difficult to trace the continuity of the canal through its strictured portion; in the case of rupture, it may be impossible to locate the distal end. Fortunately, in most cases the bladder can be drained successfully by the perineal route, thus avoiding the necessity for performing either retrograde urethral or suprapubic catheterism. If the anatomic relations of the perineal tissues have become distorted or altered as the result of traumatism or of extravasated urine, or when fruitless efforts have been made to pass a catheter, the lumen of the distal end of the canal becomes occluded, and the torn end of the tube is packed down firmly in an abnormal position among the deep structures of the perineum, rendering its detection extremely difficult or even impossible, without a resort to retrograde catheterism. In all such cases the misplaced end of the canal will usually be found either at the lower angle of the perineal wound, near the rectum, or high up, on either side of the median line, below the pubic bone. With the aid of the dilating perineal staff devised by me and following the technic advocated in operating upon such strictures without a guide, I have in every instance successfully found the distal end of the urethra and succeeded in restoring the continuity of the canal by the perineal route. If this method fails, retrograde urethral catheterism, as suggested by Young, should be tried.

Urethral Retrograde Catheterism.—The median incision is converted into one resembling an inverted Y, by making two vertical incisions branching off from the median one; these are carried downward and outward, between the tuberosity and the sphincter ani. By careful dissection, after the manner described when considering perineal prostatectomy, the apex of the prostate is exposed, the prostatic urethra found, and the edges of the urethral mucous membrane seized with hemostatic forceps, after which a Wheelhouse probe is passed from behind forward; this finds and follows the membranous urethra, thus locating the urethra both in front of and behind the stricture.

Cock's Operation.—This operation, being more or less dangerous and uncertain, has fallen largely into disuse. It is merely a palliative measure, relieving the urgent symptoms by draining the bladder, and necessitating a future operation for the relief of the stricture. The driving of a double-edged knife blindly into the depths of the membranous urethra on the chance of incising a perineum whose anatomic structures are distorted, is a method that does not appeal to the practical surgeon.

The operation necessitates the use of a double-edged knife designed for the purpose.

Suprapubic Cystotomy with Retrograde Catheterism.—This operation is performed in grave emergency cases in which as little time as possible must be lost. It is also the operation of choice in patients whose physical condition is such as to render any operative procedure dangerous, but in whom, nevertheless, surgical intervention is imperative. In performing perineal urethrotomy the proximal end of the urethra may generally be found without difficulty; when, however, this cannot be done, the search may, in the case of young, robust subjects, be continued for a considerable length of time without injury to the patient. When, on the other hand, the patient is advanced in years, feeble, with damaged heart and diseased kidneys; when there has been extravasation of urine, continuing for a number of hours and accompanied by gangrene, sepsis, or uremia; in traumatic stricture in which a portion of the urethra is practically obliterated; and in elderly subjects with retention of urine, associated with an impermeable stricture and a hypertrophy of the prostate gland—in all these cases the safety of the patient demands that the operation be performed as speedily as possible; if, therefore, thorough search fails to disclose the proximal portion of the urethra, retrograde catheterism should be resorted to without delay. This will shorten the time required for the operation, diminish shock, and tend to minimize the amount of anesthetic required, besides lessening the danger of suppression of urine, uremia, or septic pneumonia, which so frequently attend complicated cases of this kind. The safest course to pursue is to induce local anesthesia by means of cocain, and then to proceed with the suprapubic cystotomy at once. It must be remembered that the latter is merely a palliative measure, relieving the retention of urine, placing the bladder at rest, and permitting the patient, in the course of a few weeks, to regain sufficient strength and vigor to undergo the ordeal of a perineal urethrotomy. In several instances in which this method of treatment was adopted it was found, when the time came for operating upon the urethra, that what was originally regarded as an impassable stricture could now be dilated by the ordinary means, or at least sufficiently stretched to permit

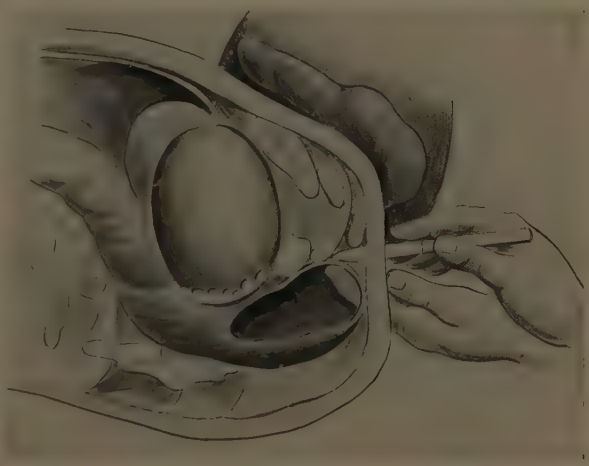

FIG. 299.—COCK'S EXTERNAL URETHROTOMY.

of the passage of the grooved urethral staff, so that perineal urethrotomy could readily be performed by means of the guide. When the bladder is distended, the operation of suprapubic cystotomy is a simple procedure that may be accomplished in about three minutes. If, on the other hand, the viscus is contracted and contains but little urine, the dissection is more difficult, and care must be observed not to injure the peritoneum. If this accident occurs, the wound should be closed immediately by a continuous catgut suture, and surrounded with iodoform gauze to prevent infection. The opening in the bladder should be sufficiently large to permit the introduction of the index-finger, by means of which the vesical outlet is easily located. and either a silver catheter or a steel bougie is

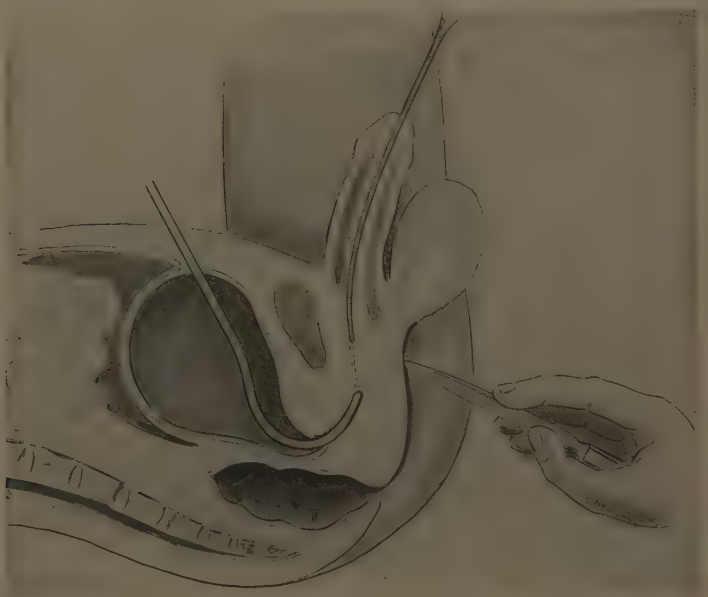

FIG. 300.—RETROGRADE CATHETERIZATION AND THE LOCATION OF THE POSTERIOR LIMIT OF THE STRICTURE.

The operator is in the act of exposing the end of the sound through a median perineal incision.

passed alongside of the finger, serving to guide the beak of the instrument into the prostatic urethra, whence it is carried outward until the tip of the instrument protrudes in the perineal wound; this will at once locate the proximal end of the canal. The dilating perineal staff is now passed through the meatus into the urethra, and carried downward until it comes in contact with the anterior portion of the stricture; the instrument in front locates the position of the urethra in front of the obstruction, whereas the one passed through the vesical outlet into the perineum establishes the proximal end behind the stricture. With these two landmarks showing the exact position of the urethra both in front of and behind the coarctation, restoration of the continuity of the canal is easily accomplished. In stout men it may be difficult to reach the vesical orifice through a

suprapubic incision. In such cases either the instrument devised by Guyon for the purpose or the overcurved prostatic catheter of Brodie may be employed. If neither of these instruments is available, a rectal rubber bag may be inserted and filled with ten ounces of water; this lifts the vesical neck well upward and places it within easy reach of the finger.

Urethrectomy.—This operation is chiefly performed in those cases of traumatic stricture that have been repeatedly operated upon without achieving permanent success, and in those in which the perineum is practically a dense mass of cicatricial tissue or is riddled with sinuses. The excision may be either partial or complete.

In performing **partial urethrectomy** the incision is made in the median line. All the cicatricial tissue in the perineum is excised, and the urethra exposed both above and below the seat of occlusion. The urethra is now incised and examined, in order to determine the extent to which the urethral walls are involved in the cicatricial mass. If only the lateral walls and the floor are implicated, these portions are resected, leaving the roof intact. A soft catheter is inserted through the meatus, and allowed to remain in the urethra until the new canal has formed.

Total urethrectomy in which a segment of the entire canal is removed is usually performed only for the relief of traumatic strictures. If more than 25 mm. must be removed, the ends of the tube cannot be approximated; if less than this is resected, the ends of the tube can usually be brought into apposition by means of four interrupted catgut sutures, which should not, however, pass through the mucous membrane. It is almost impossible to introduce a suture through the superior wall. If it is found impossible to anastomose the cut ends of the urethra, an attempt should be made to construct a urethra over the catheter; if this cannot be done, a catheter should be introduced and allowed to remain *in situ*, in the hope that the resected portion will be reformed. In three cases Wölfler transplanted the mucous membrane dissected from a prolapsed uterus. In four cases I have employed successfully the preputial lining of the foreskin immediately after circumcision. In case of permanent fistula in the perineum, or where a portion of the urethra has been destroyed by traumatism, or in resilient strictures that recontract immediately after operation, the following method, suggested by Poncet, is useful: An external perineal urethrotomy is performed; the proximal end of the urethra is exposed and sutured to the lower angle of the wound, and the distal part of the urethra is closed. In the cases so operated upon by me there was no incontinence or further trouble from urinary obstruction, the only inconvenience being that the sitting posture had to be assumed in emptying the bladder.

Electrolysis.—This method of treatment has never found favor, the only benefit that accrues from its employment being the gradual dilatation produced by the introduction of the electrode. The method not infrequently results in the development of urethritis, prostatitis, cystitis, and epididymitis.

ACQUIRED URETHRAL FISTULA.

Urethral fistulas are classified according to the position of their opening and the course pursued by the urinary tract. The various forms encountered are the urethropenile, urethroperineal, urethroperineoscrotal, urethrorectal, and urethroperineorectal. The cutaneous opening is usually observed on the under surface of the body of the penis, scrotum, or perineum, but it has occasionally been found on the posterior portion of the buttocks, the thigh, in the region of the hip, or on the lower portion of the abdomen. The opening may be so contracted that a fine wire can be inserted only with difficulty, or, on the other hand, the loss of tissue may render the opening quite extensive. The number and size of the cutaneous orifices depend on their situation, their cause, and on whether the condition is recent or has persisted for some time. The tract may be short and straight, leading directly down to the urethra, or it may be tortuous, forming a long subcutaneous channel.

Among the conditions that may give rise to the formation of a urethral fistula are stricture of the urethra; abscess of Littré's glands; periurethral abscess; phagedenic venereal ulcers; rupture of the urethra followed by extravasation of urine; suppurating gummata of the body of the organ; traumatism; strangulation of the penis due to gangrene arising from the presence of a constricting band, and impaction of a foreign body, such as a calculus, in some portion of the canal.

Perineal and scrotal fistula most commonly results from stricture or rupture of the urethra or from the lodgment of a calculus in either the deep portion of the canal or the prostate gland; occasionally it may follow in the wake of an abscess of the perineum, the prostate, or Cowper's glands, or, very rarely, it may result from traumatism.

Urethrorectal or **urethroperineal fistulas** are of very rare occurrence as compared with other forms. They have been known to follow fracture of the pelvis, extension of malignant growths from neighboring structures, tuberculous or malignant growths of the urethra or of Cowper's or the prostate gland, impacted calculi, and occasionally they are known to occur after operations upon the perineum. Rectal abscess associated with hemorrhoids has sometimes resulted in the formation of a fistulous communication between the urethra and the rectum.

Urethropenile Fistula.—Traumatism or gangrene due to constriction of the organ has occasionally resulted in the formation of a fistula of the penile urethra. The most common causes are periurethral abscess, resulting from a gonorrheal infection of Littré's glands, stricture of the urethra, and sloughing venereal ulcers. In such cases the fistulous tract is usually single, running obliquely from behind forward; occasionally it is perpendicular to the axis of the organ. It is always short and straight. The tissue of the corpus spongiosum becomes atrophied, resulting in the external and internal orifices being frequently nearly opposite each other, the skin and mucous membrane of the canal being in contact. The internal orifice is usually the larger, and is a funnel-shaped opening, tapering down to form the canal. In a recent fistula the walls are soft and

yielding, being free from induration. In cases of long standing they become hard and callous, forming an induration that feels not unlike a cord. The opening is often so markedly contracted as barely to admit the introduction of a fine wire; on the other hand, it may be from one-half to six centimeters or more in diameter. Fistulas in this situation seldom have either prolongations or diverticula. When the external orifice is large, the skin is intimately adherent to the mucous membrane and is practically continuous with it.

Symptoms.—The symptoms are so evident that no difficulty should be experienced in making a diagnosis. When the orifice is very small and the canal contracted, a doubt may exist as to whether or not the tract communicates with the urethra. This may be determined by covering the orifice with a piece of linen and directing the patient, while passing the urine, to interrupt the flow by making compression just in front of the orifice. If a communication with the urethra exists, the urine will be forced through the canal and stain the linen. In order to determine the length and course of the tract a bougie should be introduced into the urethra and the canal explored by means of either a fine wire or a filiform bougie. When the orifice of the fistula is comparatively large, the only symptom will be an interference with micturition and ejaculation.

Treatment.—This consists in removing the cause and restoring the urethra to its normal condition. Any obstruction due to stricture should be removed, and chronic inflammatory lesions should receive proper treatment. In recent cases of fistula with narrow channel and small orifice, gradual dilatation, together with continuous catheterism, should first be employed. Fistulas of this type frequently close spontaneously as soon as the condition that gave rise to them is removed. A fistulous tract of small dimensions, resulting from a periurethral abscess, should be injected with silver nitrate solution, 5 grains to the ounce. Three drops should be instilled into the canal by means of a hypodermic syringe having a blunt needle. Should this fail, the tract may be cauterized, preferably by means of fine wire heated to a dull red and introduced into the sinus. If these methods prove unavailing, or if the orifice is so large as to preclude the employment of injections or of cauterization, either urethrorrhaphy or urethroplasty must be resorted to.

Urethrorrhaphy.—This operation is indicated only in certain selected cases, plastic operations being, as a rule, far more satisfactory and giving better results. When the orifice is large and the skin and mucous membrane are intimately adherent, or when a considerable portion of the floor of the urethra has been destroyed, urethroplasty is to be preferred, for even if urethrorrhaphy is successfully performed, a narrowing of the lumen of the urethra sufficient to cause obstruction would be sure to follow. The method suggested by Voillemier is very satisfactory, but in place of the shotted suture that he advises I employ silkworm-gut. The skin and subcutaneous tissues are freshened for about half a centimeter around the fistulous opening, and the denuded surfaces approximated by means of interrupted sutures of silkworm-gut. Continuous catheterism should be maintained until the wound has healed and the sutures are removed.

Of the plastic operations, that recommended by Thiersch for the relief of epispadias (see p. 501) has given most satisfaction. A modification of the Thiersch method has been suggested by Szymanowski, and has found favor.

Szymanowski Operation.—An incision is made at a point slightly beyond the upper end of the fistulous opening, on the right side, and carried downward along the mucocutaneous margin of the orifice until it reaches a little beyond the lowest point of the mouth of the canal. A subcutaneous flap is then made, which is dissected in such manner that a pocket is formed that, when completed, will receive and cover the cutaneous flap raised from the opposite side. An incision is likewise made on the left side, beginning at the same point where the incision on the right began, and carried downward until it meets the lowest point of the incision on the opposite side. A flap is then dissected backward until the mucocutaneous margin of the fistulous opening is reached. When completed, it should be semi-elliptic in shape, and of sufficient breadth to cover over

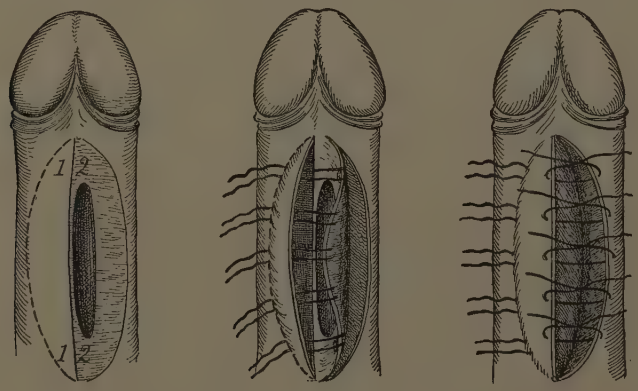

FIG. 301.—SZYMANOWSKI'S OPERATION FOR A LARGE FISTULA.

the opening of the urethra and fit into the bottom of the pocket made by the subcutaneous flap of the right side. The flap is then everted, turned under the subcutaneous flap of the opposite side, and stitched to the bottom of the pocket by means of interrupted fine silk sutures. The subcutaneous flap is then carried across and sutured to the margin of the incision in the skin on the left side. As soon as the plastic work is completed, perineal drainage should be instituted and maintained until the sutures are removed.

Neglected strictures of the penile urethra of small caliber are frequently associated with multiple fistulas of narrow lumen and having contracted orifices. In such cases the obstruction of the urethra must be relieved by means of a combined internal and external peri-urethrotomy, after which the sinus should be freely laid open and scraped by means of a sharp curet, packed with gauze, and allowed to heal by granulation. Perineal drainage should be continued until the communication between the fistulous tract and the urethra is closed.

Urethroscrotal and Urethroperineal Fistulas.—This form of fistula is more common than that of the penile variety. At the beginning the fistula is usually single, but in long-standing, neglected cases multiple fistulas occur. The cutaneous outlet is generally very markedly contracted, interfering with drainage and resulting in pus and urine being retained in the canal, giving rise to what is known as a urinary abscess, which in its turn burrows along the course of least resistance, and discharges, thus establishing a new channel. The tract may be straight, but more frequently it is quite long and tortuous, having diverticula, the result of abscess formation. At the beginning the canal is lined with a very adherent plastic lymph, which, as the result of long-standing irritation and chronic inflammation, becomes converted into channels that are narrow, and the walls of which are composed of hard fibrous connective tissue that on palpation feel not unlike a thick cord. The external orifice is much smaller than the internal opening, the former being not infrequently multiple in number, whereas the internal is usually single. Occasionally a number of openings have been observed in the deep urethra that lead into a series of channels that often unite into one main trunk, a little distance from the urethra. Urethral fistulas sometimes open into the groin, thigh, buttock, knee, loin, and lower abdomen. The size and condition of the orifice are usually dependent on the length of time the opening has existed. In recent cases it is comparatively large, and the tissues are soft and yielding; in long-standing cases, however, the opening becomes so much contracted that a bristle can hardly be inserted. The edges of the opening become indurated, and the mouth filled with small, pin-point-sized granulations.

Symptoms.—A urethral fistula is always accompanied by the presence of an irritating mucopurulent discharge. The constant leakage of pus and decomposed urine from the sinus may set up a chronic dermatitis about the fistulous opening, which becomes red and pouting. Sometimes the opening may be concealed by a fold of thickened epidermis. In chronic cases the skin of the scrotum and perineum becomes excoriated, and a low grade of inflammation is set up, which gives rise to a discharge having a fetid odor. In the course of time the cutaneous tissue of the scrotum and perineum undergoes enormous hypertrophy, becoming converted into a mass of fibrous tissue so extensive as almost entirely to conceal the penis from view. The condition is sometimes described as "pseudo-elephantiasis."

Besides the objective symptoms just described, there is more or less leakage of urine through the fistulous openings. As a rule, the diagnosis is easily made. When the fistulas are numerous and the urethra is almost impermeable, almost all the urine will be discharged through the various openings in the form of a spray, much resembling the water poured through the sprinkler of a watering-pot. When the flow of urine is only partially obstructed and the fistulous tract is of recent formation, but a few drops of urine will find their way through the channel during micturition. In doubtful cases either the pressure test, which has previously been described, or the methylene-blue test may be employed; in the latter the

blue color of the urine that leaks through the sinus will at once disclose the fact that a communication with the urethra exists.

Treatment.—Autoplastic operations in this variety of fistula are seldom, if ever, applicable. In a certain proportion of such cases—in fact, in most strictures—a spontaneous cure takes place as soon as the cause that gave rise to the condition is removed. The first step in the treatment, therefore, aims to discover the cause and remove it, if possible. The caliber of the urethra must be restored to its normal dilatability. If an obstruction due to stricture exists, gradual dilatation, when possible, should be resorted to, to be followed by continuous catheterism, in the hope of preventing the urine from coming in contact with the fistulous opening, and thus permitting it gradually to close. While this method of treatment has effected a cure in a small percentage of cases, experience has taught me that a combined external and internal perineal urethrotomy should be performed and the sinus laid open, scraped, and continuous catheterism instituted until the communication between the sinus and the urethra has become obliterated.

FIG. 302.—TUTTLE'S OPERATION FOR FISTULA. Rectum and perineum incised to expose recto-urethral fistula.

Urethrorectal and Urethroperineorectal Fistulas.—The internal opening of the fistula may be either in the membranous or in the prostatic portion of the urethra, the former site being the most common. When the orifice is in the prostatic urethra, it will be found on either side of the verumontanum. The fistulous tract is usually single, making a direct communication between the rectum and the urethra; it may be bifurcated, one branch communicating with the rectum and the other with the skin of the perineum. The channel runs obliquely from behind forward, the internal opening being at a higher level than the external. The walls of the fistula, especially in long-standing cases, are indurated, callous, and sometimes nodular. The opening is usually so markedly contracted that a fine probe may be introduced only with difficulty; or, on the other hand, when a considerable sloughing of the urethrorectal septum has taken place, the orifice may assume considerable dimensions.

Symptoms.—The irritation produced by contact with the urine frequently causes excoriation of the skin of the perineum, buttocks, and thighs. The mucous membrane of the rectum is always more or less congested and inflamed. Prostatitis is more marked in cases of urethrovesical fistula than when a communication exists between the urethra and the rectum. The fistulous opening in the rectum is usually situated just above the sphincter ani. It may be difficult to find, being covered by a fold of mucous membrane. When visible, it presents a slightly elevated appearance, the opening being covered by pin-point-sized granulations. The most marked symptom is the leakage of urine from the fistulous opening during micturition. The amount of urine discharged in this way will depend on the size of the fistulous outlet. When the orifice is very much contracted, only a few drops will be passed at a time, but if the opening is large, a considerable amount of urine will be discharged into the rectum during micturition, which may slowly dribble away, be retained, or sometimes be passed during defecation. Occasionally gas or fecal matter finds its way into the urethra; in the latter case impaction may occur, giving rise to urethral obstruction. The diagnosis of this form of fistula is easily made from the history, the symptoms, and by means of rectal palpation and exploration of the fistulous tract; for the latter purpose a metal bougie is inserted into the urethra and a Sims speculum introduced and the rectum inspected. The opening can usually be readily discovered and explored either by means of a fine probe or a filiform bougie.

Fig. 303.—Tuttle's Operation for Fistula. Recto-urethral fistula and wound in the rectum closed.

Treatment.—In this form of fistula a spontaneous cure is rarely effected. In recent traumatic cases or following suppuration that is not due to a tuberculous infection a cure may follow removal of any existing urethral obstruction, and, by means of continuous catheterism, protecting the fistula from the entrance of urine, intestinal gas, and fecal matter. Since operative interference has resulted in a large percentage of failures, it is best first to resort to palliative measures. Fistulas resulting from a tuberculous process or malignant growths are not amenable to treatment. Clinical experience has shown that the employment of stimulants, such as silver and copper, or the use of the actual cautery, is of little avail.

The indications are twofold: first, to remove any obstructions of the urethra that may exist, and, second, to obliterate the fistulous opening. This can best be accomplished by the technic suggested by Tuttle.

Tuttle's Operation.—The patient is placed in the lithotomy position. An incision is made in the median line of the superior wall of the rectum from behind forward, and carried upward, dividing the urethra, and thence outward, incising the perineum, until the junction of the perineum and scrotum is reached. By means of scissors the cicatricial tissue surrounding the urethra is trimmed away, after which the intestinal wall is dissected for three-quarters of an inch beyond the fistula, and likewise freed for a half-inch on each side. Next a flap is dissected from the soft tissues from each side of the urethra large enough to replace the portion of the floor of the canal that has been destroyed. A steel sound, No. 30 French, is passed through the urethra down to the bladder, over which the flaps are sutured, thus forming the new canal. Secondary flaps are then outside of the first flaps, and entirely surrounding them, making a sort of cuff to the first area sutured. The edges of the rectal wall are sutured in all their thickness down to the external sphincter, employing chromicized catgut for the purpose. At this point the mucous membrane is dissected loose for a short distance on each side, and drawn together by stitches so inserted as to include the muscles. The incision into the urethra just below the site of the fistulous opening is left unsutured. A soft-rubber catheter is introduced through the meatus into the bladder and fastened so that it will not slip out. The lower portion of the wound is closed by interrupted sutures. The anterior portion of the perineal incision is loosely packed with gauze, and a large drainage-tube introduced into the rectum to facilitate the escape of gas. (See Figs. 302, 303, and 304.)

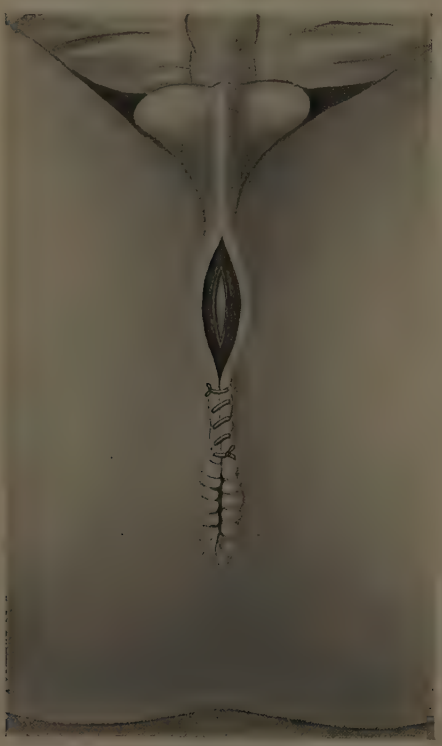

FIG. 304.—TUTTLE'S OPERATION FOR FISTULA. Final step in operation for recto-urethral fistula.

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CHAPTER LXI.

SURGERY OF THE SCROTUM, TESTICLE, SPERMATIC CORD, AND SEMINAL VESICLES.

By Arthur Dean Bevan, M.D.,

CHICAGO.

SURGICAL ANATOMY AND EMBRYOLOGY.

Before taking up the consideration of the surgery of this special region, it seems important to give a brief review of the anatomic and embryologic facts, which have a clinical bearing. The scrotum consists of and contains the following layers of tissue:

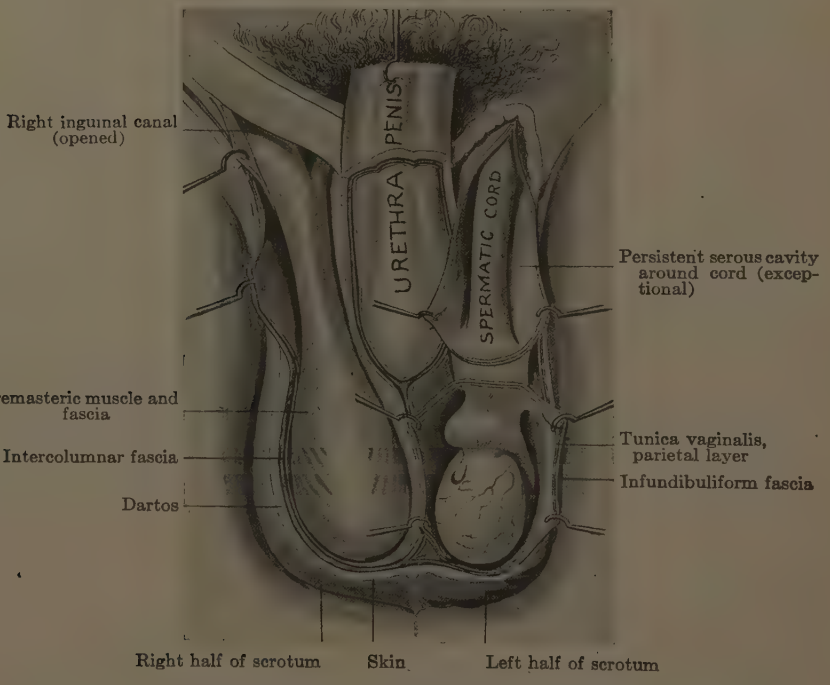

Fig. 305.—Anatomy of the Scrotum (Testut).
On the left side the cavity of the tunica vaginalis has been opened; on the right side only the layers superficial to the cremaster have been removed.

The skin, which is thin and elastic, is pigmented and marked by a longitudinal raphé and, when contracted, by transverse ridges.

The dartos, which is the superficial fascia of the scrotum, is peculiar in being elastic, in containing no fat, and in containing muscle-fibers,

which when contracted give the scrotum its corrugated appearance. The intercolumnar fascia is a thin layer of connective tissue lining the dartos. It is continuous with the intercolumnar fascia at the external inguinal ring.

The cremasteric fascia, which contains the long, pale, looped bundles of the cremasteric muscle.

The infundibuliform fascia is a prolongation of the transversalis fascia. The tunica vaginalis is derived from the peritoneum, and consists of a visceral portion closely adherent to the testicle, and a parietal portion which normally forms a closed sac situated in front of the testicle. In Fig. 305 the normal tunica vaginalis is shown surrounding the testis. Above and in front of the cord is depicted a persistent, serous cavity. This cavity normally undergoes obliteration; it persists only in such conditions as hernia or hydrocele of the cord.

The testicle (Fig. 306) consists of a fibrous covering, the tunica albuginea, which gives off numerous septa dividing the secreting structures of the gland into a number of lobules. Each lobule contains several seminiferous canals, from the epithelium of which the spermatozoa develop. These several canals unite to form a straight tube, and these straight tubes empty into channels in the mediastinum, and from here the secretion passes into the epididymis through ten or fifteen canals called the vasa efferentia.

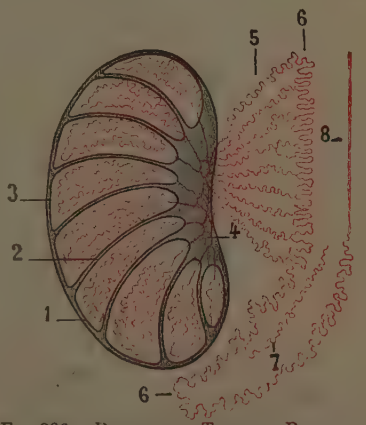

FIG. 306.—DIAGRAM OF TESTICLE PROPER AND EPIDIDYMIS (Testut).

1, Tunica albuginea; 2, trabecula; 3, lobule; 4, mediastinum with rete; 5, efferent cones; 6, 6, epididymis; 7, vas aberrans; 8, vas deferens.

These vasa efferentia form the head of the epididymis and empty into the single canal of the body of the epididymis. This is a long tube, ten to twenty feet in length, coiled up in the short space of the body and tail of the epididymis. At the tail the convoluted tube straightens out and becomes the canal of the vas deferens. A number of small, embryologic remains are found in connection with the testicle and epididymis; these are to be noted, as they at times give rise to cysts and other pathologic conditions. These embryologic remains are the pedunculated and sessile hydatids of Morgagni, the organ of Giraldés, the vas du rete, and the vas aberrans.

The spermatic cord is a composite structure composed of the vas deferens (Fig. 307), the artery of the vas, the veins of the vas, the spermatic artery and spermatic veins proper, the sympathetic nerves, and the lymphatics; these are all surrounded by the infundibuliform fascia, the cremasteric fascia and muscle, and the intercolumnar fascia. A study of the blood-supply of the cord is important. It is to be noted that the testicle is supplied by two arteries, the spermatic, a branch from the aorta, and the artery of the vas, a branch from the superior or middle vesical artery. These

arteries anastomose freely, and it has been shown by clinical results, as in operations for varicocele, and by laboratory experiment that either one can be ligated without interfering with the function of the testicle.

The anterior group of veins which accompany the spermatic artery, the spermatic veins proper, is the one chiefly involved in varicocele. These veins empty on the right side into the ascending vena cava and on the left into the renal vein. This difference, and the fact that the left vein has resting upon it the sigmoid flexure, furnishes the anatomic explanation of the great frequency of varicocele on the left side as compared with the right.

FIG. 307.—ELEMENTS OF THE SPERMATIC CORD (Campbell).
A, Vas deferens; *B*, spermatic artery; *C*, spermatic veins.

The posterior group of veins accompanying the vas is not much involved in varicocele. These veins anastomose freely with the other group and empty for the most part into the deep epigastric veins. In the operation for varicocele a section of the anterior group of veins and a section of the spermatic artery are, as a rule, removed, the artery and veins of the vas which are quite capable of carrying on the circulation of the testis being untouched. (See operation for varicocele.)

The vas is from fifteen to twenty inches in length; it can readily be distinguished from the other structures in the cord by its hard, firm consistency. It enters the abdominal cavity through the inguinal canal and at once leaves the spermatic vessels and makes a wide sweeping curve down into the pelvis to reach the lateral surface of the bladder. It then winds to the under surface of the bladder, where it becomes dilated into the ampulla of Henle, lying internal to the seminal vesicles and in close contact with the anterior wall of the rectum. The vas unites with the seminal vesicle to form the common ejaculatory duct (Fig. 308).

The seminal vesicles are two small, lobulated reservoirs for semen situated on the under surface of the bladder. They are about two inches in length and half an inch in width. When enlarged or indurated by some pathologic process, as abscess or tuberculosis, they can be felt by the palpating finger in the rectum just above the prostate.

The Descent of the Testicle.—In the first few months of fetal life the testicle is situated in the abdominal cavity below the kidney and behind the peritoneum. Attached to its lower pole is a mass of elastic and muscular tissue, called the gubernaculum testis, which passes through the inguinal canal to the bottom of the scrotum.

In the process of development a bud or process of peritoneum passes out of the inguinal canal in front of the gubernaculum into the scrotum. The gubernaculum chains the testicle to the scrotum. When the fetus is a very small organism the distance from the kidney to the scrotum is but a fraction of an inch. As the fetus grows to become the child at term, the testicle

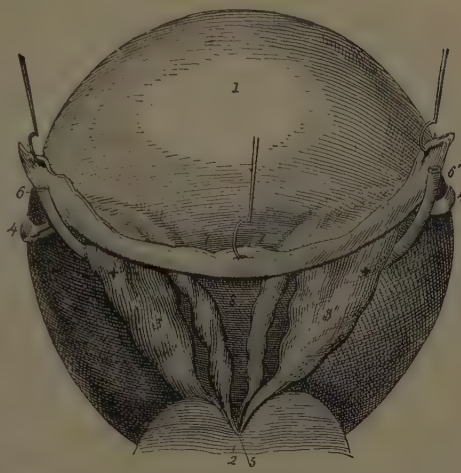

FIG. 308.—SEMINAL VESICLES AND VASA DEFERENTIA, POSTERIOR VIEW (Testut).

1, Bladder; 2, prostate; 3, 3′, seminal vesicles; 4, 4′, vasa deferentia; 5, ejaculatory ducts; 6, 6′, ureters; 7, 7, perivesicular cul-de-sac of peritoneum; 8, interdeferential triangle, in direct relation with the rectum, from which it is separated only by the prostatoperitoneal aponeurosis. The two crosses (+ +) indicate the points at which the ureters disappear in the vesical wall.

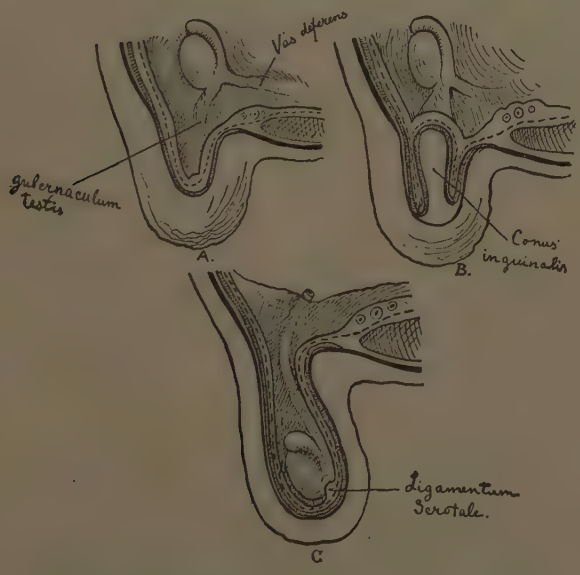

FIG. 309.—DESCENT OF THE TESTICLE IN THREE STAGES.

The process of peritoneum and the gubernaculum testis preceding the testicle into the scrotum.

gradually descends from its original position below the kidney, enters

and passes through the inguinal canal, and the scrotum becomes its habitat. The gubernaculum remains at the lower pole of the testicle as the scrotal ligament.

In this process of descent there is a period during which the peritoneal pouch in the scrotum communicates freely with the general peritoneal cavity. Normally that portion of the pouch in contact with the cord becomes obliterated, leaving unobliterated simply the portion in front of the testis, a portion which becomes the tunica vaginalis.

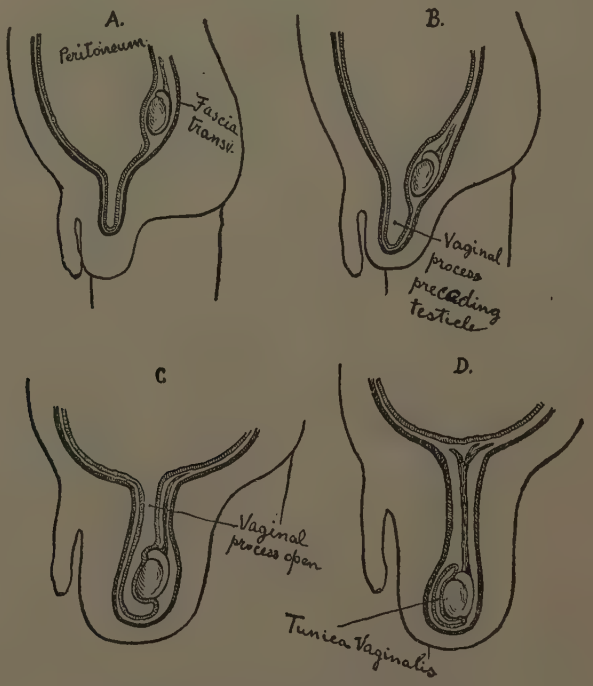

FIG. 310.—THE DESCENT OF THE TESTICLE.

A, First position of testicle, below the kidney and behind the peritoneum; *B*, testicle passing through the canal; *C*, testicle in scrotum, with open vaginal process, so that the general peritoneal cavity and the future tunica vaginalis are still continuous; *D*, the vaginal process obstructed, the general peritoneal cavity shut off from the tunica vaginalis.

Failures in normal development may result in undescended or misplaced testicle, congenital hernia, hydrocele of the cord, etc.

UNDESCENDED AND MISPLACED TESTICLE.

Undescended or misplaced testicle occurs in about one out of five hundred individuals, as shown by the physical examination of recruits for the Austrian army. There are four types of undescended testicle: (*a*) Where the testicle is in the abdomen nearly in or about its original position; (*b*) where the testicle is at the internal ring; (*c*) where the testicle is in the inguinal canal; (*d*) where the testicle is external to the external ring.

Misplaced testicle may be situated either (*a*) in the perineum or (*b*) on the thigh at about the position of the femoral hernia. The malformation is one of importance from both a physical and a psychic standpoint and deserves more consideration than has been generally given it. Most text-books on surgery dismiss it with a few words. The sufferers have in the past been offered no relief for the deformity and have usually been advised to have the organ removed if it caused any discomfort. It has, however, been shown within the last few years that by a careful dissection the testicle can in almost all cases be replaced and retained in the scrotum.

The dangers and discomfort of an undescended testicle are much greater than those caused by the ordinary inguinal hernia and call much more urgently for operative relief. The dangers are briefly as follows: (1) The existing or potential hernia. (2) The tendency to serious lesions—

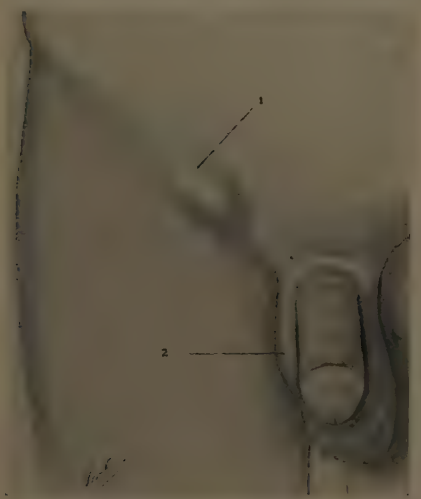

FIG. 311.—UNDESCENDED RIGHT TESTICLE.

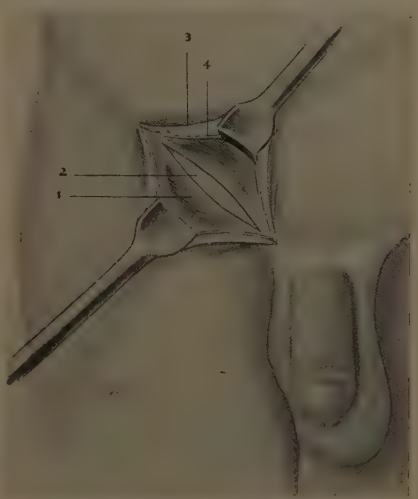

FIG. 312.—BEVAN'S OPERATION.

Incision through skin (3), superficial fascia (4), and external oblique (1); 2 cremasteric fascia.

epididymitis, atrophy, twisting of the cord with resulting gangrene, etc. (3) Injuries from its exposed position, by external violence or muscular exertion. (4) The probability of malignant disease. (5) Worry and mental depression which may result from the deformity.

The term monorchid is sometimes used to describe the individual with but a single testicle in the scrotum. Kryptorchid means the individual without a testicle in the scrotum. In thirty-four operations which I have performed there were five cases in which the malformation was bilateral.

Max Schueller, in 1881, was the first to publish a successful operative plan for undescended testis. He recognized the fact that the most important obstacle to reduction is the vaginal process of the peritoneum, and to overcome this he recommended the transverse division of this process and stitching the testicle into the scrotum.

The Schueller operation was a great step in advance, but did not go far enough. It has a limited field of usefulness and claims few adherents. The operative method which I have developed and employed in more than thirty cases meets the indications better and has a wider field of application.

My method has been developed to such a point that testicles which lie entirely within the abdomen can in almost all cases be brought down and retained permanently in the scrotum. The operation can be performed at any age; but where the time can be selected, probably the period from ten to twelve should be chosen.

Technic of Operation.—The technic is as follows: An incision is made about three inches long over the inguinal canal (Fig. 312). This cut should divide skin, superficial fascia, and the aponeurosis of the external

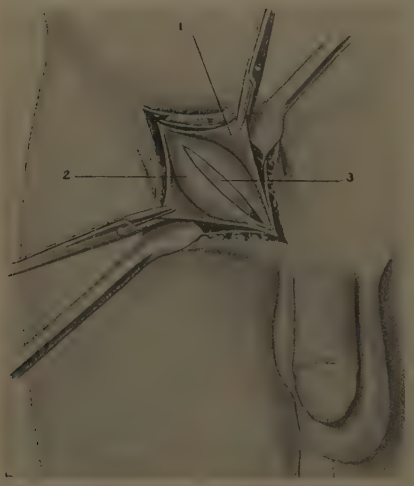

FIG. 313.—BEVAN'S OPERATION.

Cremasteric fascia divided. External oblique reflected. 1, External oblique; 2, cremasteric fascia; 3, peritoneal pouch.

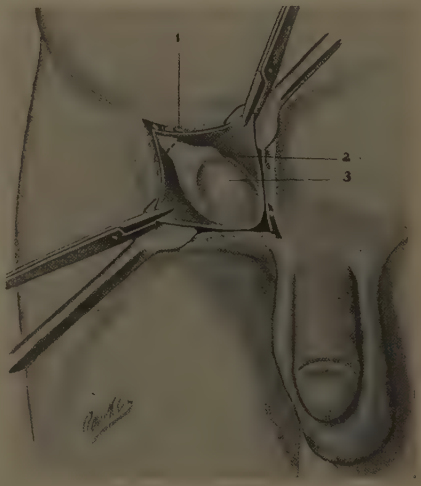

FIG. 314.—BEVAN'S OPERATION.

1, Point where vaginal process of peritoneum is cut; 2, vaginal process open, exposing the testicle; 3, testicle.

oblique. Under the external oblique will be found a pouch of peritoneum extending from the abdominal peritoneum through the canal and down to the scrotum. Sometimes the pouch extends to the bottom of the scrotum even in cases in which the testicle has never been out of the abdominal cavity. This pouch of peritoneum is covered by the cremasteric muscle and fascia and the transversalis fascia. These thin layers should be divided and the peritoneal pouch opened (Fig. 313). The vaginal process of peritoneum should be divided transversely well above the testicle. Care should be taken not to injure the cord, and in children, where the peritoneal process is as delicate as tissue paper, the dissection must be made with great care and with small instruments (Fig. 314). After complete transverse division of the vaginal process the upper end is closed with a catgut ligature, as is the sac in a hernia operation, and the lower end is closed with a purse-string suture, making a tunica vaginalis for the testis (Fig. 315).

Then, with a gauze sponge, the peritoneum is carefully wiped off from

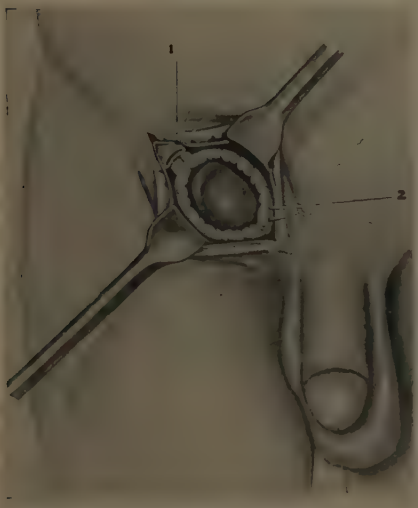

FIG. 315.—BEVAN'S OPERATION.

1, Upper end of vaginal process of peritoneum ligated; 2, purse-string suture closing lower end of vaginal process and forming a tunica vaginalis for the testicle.

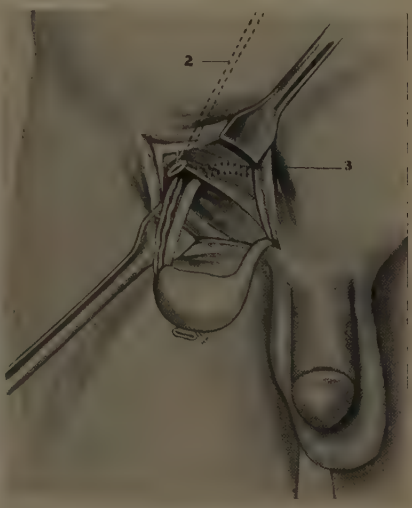

FIG. 316.—BEVAN'S OPERATION.

Cord lengthened and testicle freed and ready for replacement; 2, the spermatic vessels; 3, the vas deferens.

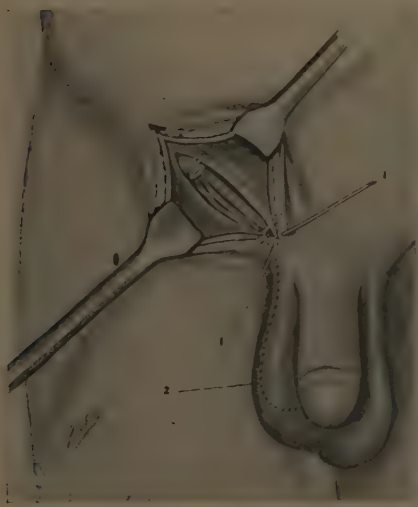

FIG. 317.—BEVAN'S OPERATION.

Testicle placed in scrotum (2) and retained by purse-string suture (1, 1).

FIG. 318.—BEVAN'S OPERATION.

Making pocket in right side of scrotum for reception of the testicle.

the cord. As the wiping proceeds the cord will gradually lengthen until the testicle can be brought well down upon the thigh. Tense fibrous strands

in the cord are to be torn either with the fingers or blunt dissecting forceps

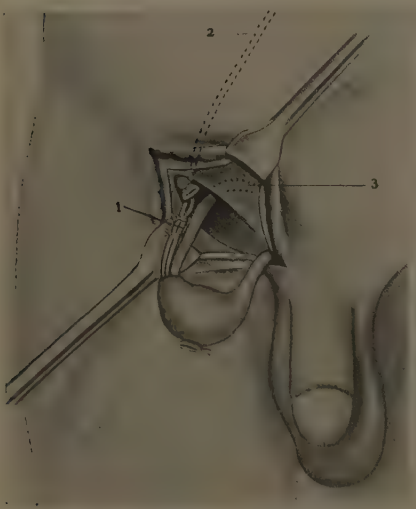

FIG. 319.—BEVAN'S OPERATION.
1, Spermatic vessels ligated and divided (this is seldom necessary); 2, spermatic vessels; 3, vas deferens and vessels.

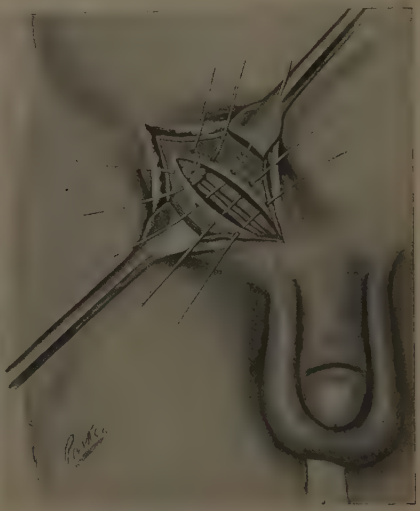

FIG. 320.—BEVAN'S OPERATION.
Sutures closing the wound.

and the cord is to be freed of everything except the vas and vessels (Fig. 316). When, as in the exceptional case, a large peritoneal pouch extends to the bottom of the scrotum, the testicle can now be pushed into this and retained by a purse-string suture within the neck of the scrotum (Fig. 317). As a rule, however, it is necessary to make a cavity by blunt dissection with the finger (Fig. 318).

FIG. 321.—CHILD OF TWO; TESTICLE FOUND AT EXTERNAL RING COMPLICATED WITH HERNIA WHICH HAD BEEN STRANGULATED; TESTICLE NOW WELL DOWN IN SCROTUM.

In a few cases—but these will be quite the exception—it is found, even after the free exposure of the cord, that it is not long enough to permit of the reduction well into the scrotum. In such cases it will be seen that the shortened structures are the spermatic artery and veins. These can be divided between two ligatures, care being taken to avoid injury to the vas and the vessels of the vas. It will then be found that the testicles can by gentle traction

be brought down sufficiently to replace it in the scrotum without tension. As has already been stated in the discussion of the surgical anatomy of this region, the artery of the vas and the veins of the vas are quite sufficient to supply the entire testicle after the ligation of the spermatic artery and anterior group of veins (Fig. 319).

The wound is now closed as in an ordinary hernia operation, not transplanting the cord, as is done in the Bassini operation, but allowing it to remain in its normal position (Fig. 320). The success of the operation depends upon freeing the testicle so completely that it can be placed in a roomy pocket well down in the scrotum without tension. Of thirty-four operations thirty have been completely successful (Figs. 321–323).

FIG. 322.—BOY OF ELEVEN; TESTICLE IN THE CANAL BEFORE OPERATION; NOW WELL DOWN IN SCROTUM.

FIG. 323.—MAN OF THIRTY; TESTICLE HAD NEVER BEEN OUT OF THE ABDOMINAL CAVITY; NOW WELL DOWN IN SCROTUM.

In two of the early cases where the testicle was not furnished with a tunica vaginalis the organs became shriveled up in a mass of connective tissue. I believe that it is very important to save the tunica vaginalis in these cases. In one case a hydrocele developed in the new tunica vaginalis. This, however, was cured by withdrawing the fluid and injecting five minims of carbolic acid, and a fourth case operated upon disclosed a testicle no larger than a pea; this case amounted practically to an exploratory operation and is simply included to call attention to this possibility. It

is the only one in the series, however. In all the other cases organs of fair size or of normal size were found. (The treatment and technic of operation of displaced testicle, whether in the perineum or on the thigh, are practically the same as those for undescended testis, and, as a rule, the reduction can be readily accomplished.

Among other malformations of the testicle should be mentioned anorchism (absence of one or both testicles, with usually other evidence of failure of development); rudimentary development and supernumerary testicles (three or more). Almost all of these supposed cases of supernumerary testicle, however, on careful examination, have proved to be instances of diagnostic error. The third body is nearly always a neoplasm or cyst.

INJURIES AND DISEASES OF THE SCROTUM.

Injuries.—Contusions of the scrotum are frequently caused by kicks, injuries from the pommel of a saddle while horseback-riding, blows with the fist and other objects capable of producing blunt force. These injuries result in hemorrhage of more or less extent, depending upon the nature and degree of the force. Slight injuries are followed by little swelling and ecchymosis, which disappear in a few days. Severe injuries of this character may result in extensive extravasations filling the scrotum and extending into the perineum and up over the abdomen. As a rule, these collections of blood are absorbed rather rapidly, and for treatment require nothing further than rest and support with bandages. Sometimes they persist and demand incision and drainage. Occasionally the blood-clot becomes infected, with resulting symptoms of sapremia or sepsis, demanding thorough evacuation and drainage and hot, moist, boric acid dressings, rest in the recumbent position, and elevation of the scrotum by a triangular bandage. Fig. 338, p. 618, shows the triangular bandage.

Wounds of the scrotum, like wounds of other structures, may be incised, penetrating, or lacerated. Gunshot wounds are seen in military practice and occur occasionally in civil life. Self-inflicted wounds made with knife or sickle or razor are met with, especially in the insane. A wound of the scrotum, if of sufficient extent, may be accompanied with prolapse of one or both testicles. Special care is required to sterilize and maintain sterilization in scrotal wounds. If infection is present, or if, from the nature and character of the injury, infection is probable, the wound should not be closed completely with suture, but provision for drainage should be made. If one or both testicles have prolapsed, they should be replaced and the wound should be closed sufficiently to prevent a recurrence of the displacement.

Acute Inflammations of the Scrotum.—Acute inflammations of the scrotum include infected wounds, furuncles, phlegmons and erysipelas, inflammations of mycotic origin, and acute reactions resulting from chemical irritants, such as poison-ivy, strong carbolic acid and corrosive sublimate dressing, etc. The delicate integument of the scrotum is so susceptible to strong antiseptics that these should never be left in contact with it for any considerable period. A 1:1000 or even 1:5000 moist bichlorid

dressing left on the scrotum overnight in preparing the field for operation is frequently followed by such swelling and chemical dermatitis as to necessitate the postponement of the operation.

Furuncles and infected wounds present nothing distinctive to distinguish them from like lesions in other regions. Erysipelas of the scrotum is distinguished by a tendency to gangrene in the severe cases. Sometimes the entire scrotum is lost and the testicles are left uncovered. It is remarkable, however, how completely a new scrotum may be formed. The granulation tissue covering the testicles contracts and gradually draws the remnants of the scrotal tissue over these organs. A plastic operation may, however, be required in order to cover the testicles with skin.

Fig. 324.—Cancer of the Scrotum (von Bergmann, von Bruns, and von Mikulicz).

In erysipelas of severe type, several linear incisions parallel with the raphé should be made to relieve tension and prevent gangrene. Gangrene of the scrotum occurs from a number of other causes—acute infectious diseases such as typhoid fever, scarlet fever, etc., phagedenic chancre, infected wounds, and phlegmonous suppuration. These are to be handled on the general surgical principles of relief of tension, evacuation of inflammatory products, drainage, and the continuous application of moist, mild, antiseptic dressing, such as boric solution.

Elephantiasis.—Elephantiasis of the scrotum is a disease found in certain tropical countries (Egypt, India, Java, Congo Free State, etc.). It is almost limited to the dark-skinned native; whites are seldom attacked. The scrotum becomes enormously enlarged, weighing sometimes fifty pounds or more. (See Vol. II, pp. 595 and 596, Figs. 475, 476, and 477.) The cause of the disease is the parasite filaria sanguinis hominis, which Manson has shown is introduced into the body by the bites of certain kinds of mosquitos. The only successful treatment seems to be the surgical re-

moval of the scrotal mass, with the formation of flaps to cover the penis and testicles from the thin normal skin of the body which has been dragged down by the weight of the tumor. Fortunately these operations have been exceedingly successful. The cases of lymph scrotum which occur in this country, and to which the name elephantiasis nostras is sometimes applied, are not due to the filaria sanguinis hominis, but to obstructive lesions of the lymph-channels and veins. These cases occur after complete removal of the inguinal lymphatics, after chronic lymphadenitis, etc.

Tumors of the Scrotum.—Various benign, mesoblastic tumors occur in the scrotum and call for no special comment. Melanotic sarcomata of this region are usually very malignant and rapidly fatal.

Cancer of the Scrotum.—Carcinoma of the skin of the scrotum is not common in this country. Cancer of the scrotum is without any special features to distinguish it from cancer occurring in other regions (Fig. 324).

A singular form, known as chimney-sweep's cancer, was at one time quite common in England among the men employed as chimney-sweeps. The relationship between their occupations and the disease seems to be found in the chronic irritation of the scrotal integuments by the soot.

A similar form of cancer is found among tar and paraffin workers. Cases of carcinoma peculiar to certain occupations seem to be like the carcinoma of the hands among *x*-ray workers, the result of a chronic dermatitis, produced by some agency peculiar to their employment, and which dermatitis favors in some way the development of carcinoma. The treatment of cancer of the scrotum is like that of cancer elsewhere; that is, early and radical removal of the disease. The prognosis is favorable if the operation is done before there is any glandular involvement.

DISEASES AND INJURIES OF THE TUNICA VAGINALIS AND SPERMATIC CORD.

Hematoma and Hematocele.—After injuries of the coverings of the testicle there may develop a hematoma within the scrotum. The usual position of the accumulation of blood is between the tunica vaginalis and the other coverings of the testicle and cord, *i. e.*, the infundibuliform fascia, cremasteric fascia, and intercolumnar fascia. This form is best described as a hematoma or a hematocele external to the tunica vaginalis. The amount of blood poured out varies in amount, but may be very great. The resulting swelling is usually pear-shaped, the large end below and the smaller extending up along the spermatic cord. As a rule, the blood-clot is soon absorbed, and the only treatment required is rest and the application of a supporting bandage. If the fluid collection persists, or if it becomes infected, evacuation and drainage are called for.

Hematocele.—The term hematocele applied to this region should be limited to an effusion of blood in the tunica vaginalis. This lesion is quite rare as compared to the extravaginal hematoma just described. Two distinct varieties occur: the traumatic and the pathologic. The traumatic form occurs occasionally after contusions to a normal testis, or more frequently as the result of hemorrhage into the tunica vaginalis

following the puncturing of a hydrocele or a traumatism to a hydrocele by some blunt force:

In some cases the blood-clot is soon absorbed, but this is not as certainly the result as in extravaginal hematoma. In cases occurring in pre-existing hydroceles the rule of treatment should be to open the sac, remove part of the sac if it is extensive, turn out the blood-clot, and stitch the sac to the integument, as in the radical operation for hydrocele. The pathologic form of hematocele is due to a chronic hemorrhagic inflammation of the tunica vaginalis with resulting thickening of this membrane.

A hemorrhagic, fibrinous exudate replaces the smooth endothelial lining. The thickened sac may undergo calcareous degeneration and in rare cases it even becomes ossified. The exact pathology is not known. The course is a chronic one. It is most common in old men suffering with chronic vascular changes. There is frequently a history of a traumatism, but its relation to the process is not clear. The differentiation between the pathologic and traumatic varieties is not always possible. There may be a single hemorrhage, but usually there are repeated hemorrhages during the course of the disease. The differential diagnosis must be made between hydrocele and neoplasms of the testicle. The aspirating syringe is the most useful means of making this differentiation. The disease seldom goes on to a spontaneous cure.

FIG. 325.—HEMATOCELE (Kocher).

The **treatment** is the radical removal by careful dissection of the entire sac and closure with temporary drainage. Hematoceles of the cord, both traumatic and pathologic, may occur in cases in which the vaginal process in front of the cord persists. They differ in no way from the hematoceles of the tunica vaginalis proper, except in anatomic location. They are exceedingly rare.

An injury which I have seen in one case only should be noted especially because of the possible error which may be made in diagnosis. It is traumatism followed by thrombus of the spermatic veins. Some weeks after the injury the clinical picture was a nodular cord which was mistaken for tuberculosis of the vas and epididymis. On operation the epididymis and vas were seen to be normal and the lesion was found to be a firm thrombus in a spermatic vein.

Acute Hydrocele.—Acute inflammation of the tunica vaginalis may occur in the course of acute gonorrheal epididymitis as a distinct complication. A limited involvement of the tunica vaginalis in epididymitis is very common. An acute hydrocele may occur also in cases of tuberculous or syphilitic lesions of the testicle and epididymis, either

with or without secondary pyogenic infection, also in the course of acute infectious diseases, as mumps, typhoid fever, etc.; also as a result of the injection of irritating fluids, such as iodin solutions and carbolic acid employed to cure a chronic hydrocele. Occasionally a direct infection of the tunica vaginalis results from the use of unclean methods in the operation of tapping a hydrocele.

The diagnosis is made from the acute onset, the swelling, the redness, the sense of fluctuation, the pain and tenderness, and the translucency of the swelling. In doubtful cases the diagnosis may be confirmed by withdrawing some of the fluid with a hypodermic needle and syringe. The treatment demanded is rest in the recumbent position, the support of the scrotum with a triangular bandage, and the application of hot fomentations.

In uncomplicated cases the condition is transient and the swelling and other symptoms disappear in from a few days to two weeks. In very severe cases accompanied by great pain and tension, incision, and drainage with a strip of gutta-percha, is indicated. This plan usually gives great and immediate relief.

An acute suppurative inflammation of the tunica vaginalis may begin as such or the simpler acute inflammation above described may become suppurative. The symptoms are the same as in the simple variety, but more intense. The swelling is not as translucent and the tendency to recovery is wanting. The constitutional symptoms of a suppurative process—that is, a chill, elevation of temperature, and increase in the leukocyte count—are present. The diagnosis is to be confirmed by the aspirating syringe. The treatment is free incision (probably best done under nitrous oxid anesthesia), free drainage with a wide strip of gutta-percha tissue, the application of hot boric acid compresses, and elevation of the scrotum with a triangular bandage.

Acute Hydrocele of Cord.—This condition, except for the difference in anatomic position, is the same as acute inflammation of the tunica vaginalis proper. It occurs only in those cases in which there is a persistent peritoneal sac in front of the cord, and is more common in children than in adults. It is sometimes very difficult to make a differential diagnosis between this condition and strangulated hernia. As a rule, the translucency of the swelling and the absence of severe or obstructive symptoms furnish the necessary evidence. If the diagnosis is doubtful, an exploratory operation should be performed. Otherwise, acute hydrocele of the cord is to be treated by the same rules as acute hydrocele of the tunica vaginalis proper.

Hydrocele; Chronic Inflammation of the Tunica Vaginalis.—Hydrocele is an accumulation of fluid within the tunica vaginalis without any acute symptoms. The lesion is a common one and may occur at any period of life. It is frequently met with during infancy. Krönlein's statistics give 48.8 per cent. of all cases in children under five years of age. My own observations do not confirm this, and are more in keeping with the statistics of Braman, who found 70 per cent. of his series of about five hundred cases in adults and but 30 per cent. in children.

The pathology is not perfectly clear and is not the same in all cases. It is generally agreed that the most common cause is traumatism, and this is differently estimated as being the cause in from 30 to 70 per cent. of the cases. The second cause in point of frequency is gonorrheal inflammation, either with or without evident involvement of the epididymis. This is estimated to be the cause in from 10 to 20 per cent. of the cases.

As other causes of hydrocele are to be mentioned tuberculosis, syphilis, typhoid fever, and neoplasms. As a rule, in these cases the hydrocele is overshadowed by the main pathologic process, and yet I have several times found, in operating by the open method in hydroceles which had existed for some time, small foci of tuberculosis in the epididymis. In these cases the hydrocele sustains about the same relation to the disease of the epididymis that a tuberculous pleurisy does to the lesion in the lungs. I am inclined to believe that tuberculosis is more frequently the etiologic factor in hydrocele than is generally admitted. Another cause is a lesion of the hydatids of Morgagni and a small spermatocele, which is within the tunica vaginalis.

The fluid in a hydrocele is, as a rule, clear and transparent; it is sometimes yellow or brown and in long-standing cases may contain cholesterin crystals. Not infrequently it is cloudy, and in these cases I have often found spermatozoa. Tuffier reports finding tubercle bacilli in two cases.

Symptoms and Course.—Hydrocele usually runs a silent course, and the patient's attention is first attracted by the enlargement of the scrotum or a sense of dragging on the cord by the increased weight. As the swelling increases it may become distressing because of the weight, or the friction of the clothing may produce a chafing of the skin and resulting dermatitis. The hydrocele of the tunica vaginalis is egg-shaped or pear-shaped. It gives the sense of fluctuation most distinctly and is translucent to light. This last sign, which is made much of by the text-books and by those of limited experience, is seldom sought for by the experienced surgeon. The differential diagnosis must be made between hydrocele, spermatocele, hernia, neoplasms, and chronic inflammation of the testis. From hernia it can be distinguished by absence of the transmission of impulse on coughing, and especially by examining the spermatic cord, as it makes its exit from the external ring. In hydrocele the spermatic cord can easily be felt. It is of normal size and enters a normal external ring. In a hernia, which might be mistaken for hydrocele as far as the scrotal tumor is concerned, this same examination will show a thick mass of tissue continuous with the scrotal swelling entering the external ring, and the normal spermatic cord cannot be made out.

The exquisite sense of fluctuation, the translucency, and the absence of the hard, firm feel of a solid tumor, as a rule make the diagnosis easy between a hydrocele and a neoplasm, but this easy differentiation is not, however, always possible. I have seen one of the great masters of surgery demonstrate a case to his class as a solid tumor of the testicle and find, upon cutting into the mass, that it was a hydrocele with very thick,

unyielding walls, so tensely distended with fluid that no sense of fluctuation could be made out.

In doubtful cases an aspirating syringe will determine the diagnosis. Spermatoceles are, as a rule, small cysts placed near the head of the epididymis, and the examining fingers can feel the testicle and the spermatocele as two distinct masses within the scrotum.

Chronic inflammations of the testis and epididymis are not infrequently accompanied with a hydrocele, usually of small size; when the hydrocele is of considerable size, it may so surround the essential pathologic lesion that this cannot be clearly made out until the fluid is withdrawn, and then, instead of finding a normal testicle as in simple hydrocele, a hard, enlarged, frequently more or less irregular mass, the result of a tuberculous or syphilitic process, is discovered.

In addition to hydrocele of the tunica vaginalis, several other forms are met with: hydrocele of the cord; hydrocele communicating with the general peritoneal cavity; hydrocele in a hernial sac; hour-glass-shaped hydrocele, hydrocele bilocularis, which may be either extra-abdominal or intra-abdominal.

Hydrocele of the cord is especially common in infancy. It is due to a persistent peritoneal pouch about the cord which becomes distended with fluid. It is frequently mistaken for hernia. I often have these children brought to the clinic with the statement that the hernia cannot be retained with a truss, and find on examination no hernia, but a hydrocele of the cord. Usually the diagnosis can be made from the sense of fluctuation and the delicate bluish color of the sac, showing through the thin integument.

Many of these cases which extend well up into the canal give a distinct impulse on coughing. The diagnosis is to be confirmed by the fine needle of a hypodermic syringe. A rare form is a hydrocele communicating with the general peritoneal cavity through a persistent vaginal process. This gives the interesting clinical picture of disappearance of the swelling when the patient assumes the recumbent position, and it is on this account difficult to distinguish from a reducible inguinal hernia. A needle should not be employed in these cases as a means of diagnosis, nor should any form of injection treatment be adopted, but an open operation, such as is employed in congenital inguinal hernia, should be carried out, because of the uncertainty of diagnosis, because of the fact that this form is often associated with hernia, and because of the great dangers to which the patient would be exposed by injecting irritating fluids into the sac, when these fluids may find their way into the general peritoneal cavity. Hydrocele in an old hernial sac may occur when the neck of the sac becomes closed by adhesive inflammation, as, for instance, from the wearing of a truss, and later the development of a hydrocele in the closed-off hernial sac. Depending upon the size of the sac, such a hydrocele may simulate a hydrocele of the cord or one of the tunica vaginalis proper.

Hour-glass-shaped hydroceles of two distinct varieties occur—one extra-abdominal, the other intra-abdominal. In the extra-abdominal type there are two sacs, one in the scrotum and one in the groin, connected

by a narrow channel surrounding the cord. In the intra-abdominal type one sac is in the scrotum and one in the abdomen, connected by a narrow process of peritoneum passing through the inguinal canal. In one case which I operated upon the scrotal sac was as large as two fists, and the intra-abdominal tumor was almost as large as a pregnant uterus. The two contained more than a gallon of fluid (Fig. 326).

In recent hydroceles the tunica vaginalis is thin and delicate, almost normal in appearance. In hydroceles of old standing the tunic may become much thickened and altered. I have seen the tunica vaginalis half an inch in thickness and of almost cartilaginous hardness. Occasionally calcareous plates are found in it.

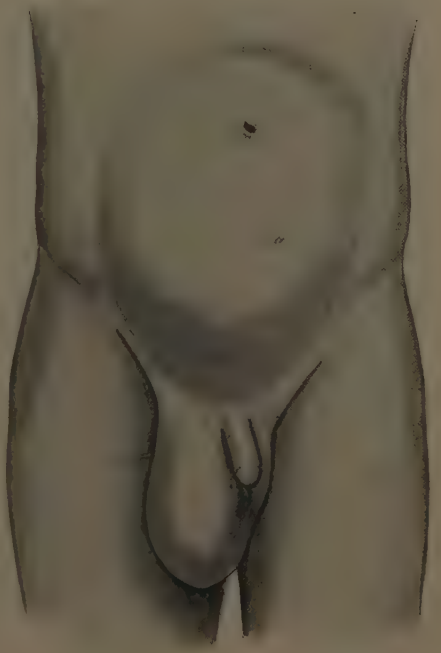

Fig. 326.—Tumor.
Hour-glass hydrocele, intra-abdominal type.

Treatment.—The treatment of hydrocele can be well divided into palliative and radical, and the radical be again divided into treatment by injection and treatment by open operation. The palliative consists of tapping and removal of the fluid with trocar and cannula, and repeating this as often as the fluid accumulates in sufficient amount to cause discomfort. In a small percentage of cases the simple tapping is followed by cure. This palliative treatment has but a limited field of usefulness, and at the present time is to be advocated only in exceptional cases. It is a proper method when the extreme age of the patient or the existence of some serious organic lesions contraindicates even the slightest surgical interference. The treatment by injection is the simplest method and is to be employed in the majority of cases.

Formerly the tincture of iodin or a solution of iodin in iodid of potassium were employed. These fluids, however, had the disadvantage of causing great pain, and they have been largely displaced by the injection of 95 per cent. of carbolic acid, first introduced by Levis, of Philadelphia.

In order to be safe and successful this operation must be carefully and properly carried out. The technic is as follows: The scrotum is sterilized by shaving and scrubbing with soap and water and alcohol as for any aseptic operation. A half dozen drops of 1 per cent. solution of cocain are injected into the scrotal integument in front and a little

above the center of the swelling; through this cocainized area a fairly large trocar and cannula are pushed into the cavity of the tunica vaginalis. The position of the testicle, which is posterior, should be kept in mind and care must be exercised not to injure this organ with the trocar. (See Fig. 327.) The trocar is withdrawn and the cannula is pushed well to the upper limit of the sac and the fluid is allowed to escape. It is important that all the fluid should be withdrawn, and in order to insure this, it is best to withdraw the last of it with a half-ounce aspirating syringe, which fits the cannula. Leaving the cannula in place at the upper part of the sac, from 5 to 20 drops of a 95 per cent. solution of pure carbolic acid are now injected into the sac and the cannula is withdrawn. As this is done the part of the sac through which the cannula passed should be grasped with the thumb and finger firmly and held for four or five minutes, while with the other hand the sac is kneaded so as to bring the carbolic acid in contact with all parts of the wall of the hydrocele. Following the

FIG. 327.—TAPPING A HYDROCELE.

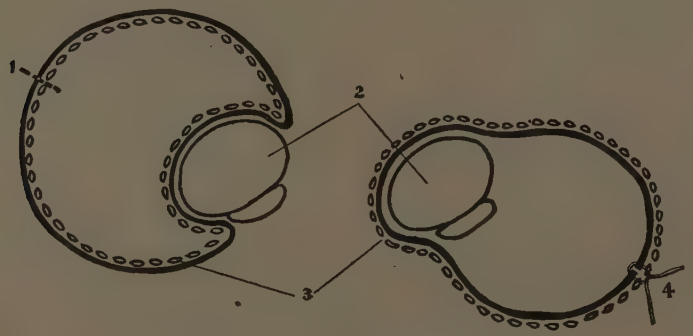

FIG. 328.—JABOULAY'S OPERATION FOR HYDROCELE.

injection, there is usually a very brief period during which there is pain and burning, but this soon subsides.

The patient should be advised to remain quiet and at home for a few days. A certain amount of reaction follows the injection. Usually the scrotum swells up to about half the size it was before the withdrawal of the fluid. This swelling gradually disappears, and in successful cases

the fluid which collected during the reaction is entirely absorbed within from three to six weeks. The treatment, if properly employed, is successful, and the lesion is cured by one injection in more than 80 per cent of the cases. A second or even a third injection may be necessary, and may be successful. The injection treatment is indicated only for those cases which have a thin-walled sac. In the old-standing cases with thick, indurated sacs the injection treatment usually fails.

The open operative methods are three in number: (*a*) the incision and drainage of the sac, (*b*) the removal of the sac, and (*c*) the Jaboulay operation—splitting the sac and turning it inside out, folding it about the testicle and cord, and stitching it in this position, so that the smooth endothelial lining will be brought in contact with the raw connective tissue of the scrotum, to which it will become adherent (Fig. 328).

FIG. 329.—E. WYLLYS ANDREWS' "BOTTLE OPERATION" FOR THE RADICAL CURE OF HYDROCELE.

Hydrocele and testis enucleated. Incision at anterior upper portion.

E. Wyllys Andrews describes his bottle operation in the following way:

"A new technic which I have used exclusively in the last two and a half years seems to me such an improvement in certainty and speed that I recommend it without reserve, and do not hesitate to urge that it supersede the older operations. The method, which I think is described very aptly by the term 'bottle operation,' brings about a complete eversion of the whole lining, without the use of stitches, and with much less cutting than the Jaboulay method.

"*Technic of the 'Bottle Operation.'*—An anterior scrotal incision is made as in the older methods. The skin should be held tense and the dissection should be nice to the exact layer which will enucleate the translucent bladder-like mass from its bed. It is not an operation for a man over forty-five to attempt without glasses.

"Careful study of the funicular part of the sac is now to be made. Usually a little funnel continues one or two cm. up the cord. The extreme upper end of this marks the beginning of the cut made into the sac. This cut is vertical on the anterior border and only about 2 cm. long (Fig. 329). We enlarge it a little by stretching. Sometimes it is wholly confined to the part over the cord. The incision in the sac is prolonged to its extreme upper end along the cord if the first cut did not do this. When the sac has been emptied, it is like a bottle or bag, with a small hole at the top. Dilating this slightly with one or two fingers, the orifice is held open and the testis is pushed up into it with the other hand or the two thumbs (Fig. 330). In a moment it can be squeezed through, and the whole sac will instantly be everted with the small buttonhole so closely surrounding the cord that it is scarcely visible (Fig. 331). The quickness

FIG. 330.—E. WYLLYS ANDREWS' "BOTTLE OPERATION" FOR THE RADICAL CURE OF HYDROCELE. Eversion of "bottle" by pushing testis through small hole in upper end.

with which this can be done will surprise any one used to the older methods. It will also be seen at a glance that there is no possibility of the testis returning into the hydrocele cavity any more than with the suture method. The short incision contracts, so as to fit around the cord, and the whole sac by its elasticity seems to collapse around the epididymis with its white serous surface almost as smooth as that of the testis. I have never seen the everted sac voluminous enough to lie in wrinkles or folds, but no harm would result if it were so to act. Ordinarily, the largest hydrocele sacs when collapsed assume about the size of the testis, showing that their walls remain perfectly elastic. As yet I have not tried my method on any very opaque, hypertrophied, or thick-walled hydrocele. It is conceivable that some such old cases resulting from inflammations, in-

jections, or former operations, might be difficult to enucleate from the scrotum, or to evert after bringing outside the skin.

"The skin is quickly closed with clips or light suture, without drainage. Such wounds heal within a week. The patients get about readily on the third or fourth day, sometimes earlier. The amount of swelling about the testis is usually small, even in double hydroceles. Tenderness and pain are moderate or absent, and no fever and malaise are felt after the second day.

"This operation is very suitable for local anesthesia, and therefore can be done on the aged without risk. Its results are in striking contrast with the old packing or open method, called in Germany Volkmann's method, but really of much older date. Koenig reports that the average confinement with this method was three weeks, and also that some patients were disabled fully as long by injection treatment, which also gives a very large percentage of failures.

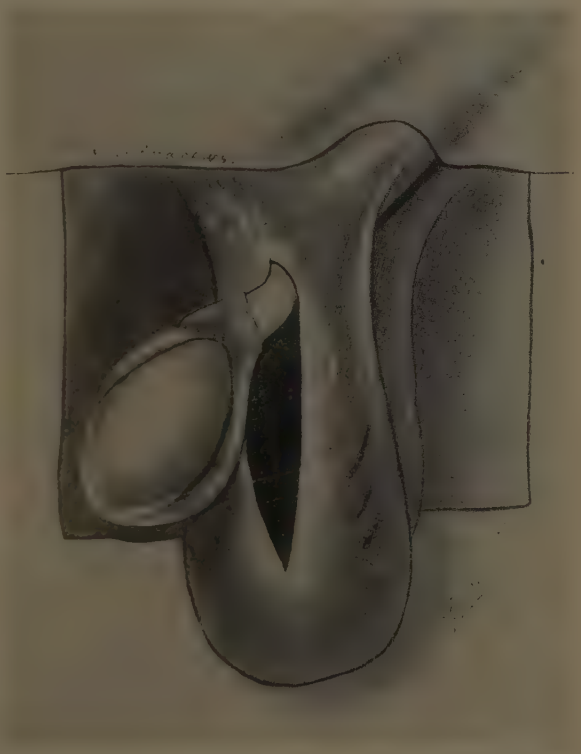

FIG. 331.—E. WYLLYS ANDREWS' "BOTTLE OPERATION" FOR THE RADICAL CURE OF HYDROCELE.
Completely everted sac. The small anterior cut now takes a posterior position around the cord. No sutures required.

"No complications have occurred in a considerable series of these operations in our clinic, and, so far as we can learn, no recurrences. The recovery has without exception been rapid and practically painless."

The incision into the sac, stitching the sac to the skin, and drainage with gauze or tube or gutta-percha tissue has been very largely employed and is curative in a very large proportion of cases. It has, however, the disadvantage that an occasional infection occurs, and in all cases there is a wound healing with granulation, which requires two weeks or more. Excision of the parietal portion of the sac is therefore to be preferred. It is not much more difficult and affords the opportunity of immediate

closure or the employment of but temporary drainage for twenty-four hours or more. This is therefore the operation to adopt when the injection method has failed, or where, from the first, it is excluded because of the character of the sac.

The Jaboulay method and Andrews bottle operations have been as yet employed in a limited number of cases. They have given very good results, can be rapidly done, and they limit the amount of dissection and resulting oozing. They should not be employed, however, where the sac is thick and indurated. All of these operations can be easily done under cocain anesthesia (1 : 1000 solution in normal salt) or under nitrous oxid gas.

The Treatment of the Rarer Forms of Hydrocele.—Hydrocele of the cord of the simple type is best treated by withdrawal of the fluid and the injection of from two to ten drops of carbolic acid. In infancy this condition frequently goes on to a spontaneous cure, and it should therefore not be interfered with for some weeks or months. If it persists or attains a considerable size, the injection operation is indicated. In a few cases, because of the thickness of the sac, excision of the sac will be required.

In hydroceles communicating with the general peritoneal cavity, and in hydroceles occurring in old hernial sacs, an open operation with excision of the sac is the only operation permissible. The injection treatment is absolutely contraindicated because of the possibility of a complicating hernia and the dangers of introducing the iodin or carbolic acid into the general peritoneal cavity. In one case I was compelled to perform laparotomy for obstructive symptoms of the bowels resulting from the injection of a solution of iron into a hernial sac. The fluid had passed freely into the peritoneal cavity and produced extensive adhesions.

In hydrocele of the hour-glass type, whether of the extra-abdominal or intra-abdominal variety, I have found the best treatment to be incision of the sac in the scrotum, stitching to the external integument, and introducing a drainage-tube to the extreme limits of the upper sac. The tube is to be gradually shortened from day to day as the sac contracts and becomes obliterated by the adhesive inflammation set up by the presence of the tube. In order to insure asepsis and at the same time secure the necessary degree of obliterative inflammation, the sacs may be irrigated daily with an iodin solution about the color of sherry wine, which is made by mixing the necessary amount of sterile water with tincture of iodin. The extensive operations which would be required to dissect out these sacs are not to be advised, as the treatment above outlined is much safer and has proved very efficient.

Varicocele.—Varicocele consists of a dilatation and elongation of the veins of the spermatic cord. The spermatic veins proper, the pampiniform plexus, is chiefly involved and the veins of the vas only to a limited degree. The condition is a common one. Senn found that about 25 per cent. of recruits which he examined for the American volunteer army in 1898 suffered from varicocele to some degree, but he rejected but two out of about ten thousand men because of this condition.

Curling found that 23 per cent. of recruits for an English army presented some degree of varicocele. The statistics of the French army gave 10 per cent. suffering from varicocele. The lesion is almost entirely limited to the left side, if only one testicle is involved. Statistics vary on this point; it is probably fair to say that out of one hundred cases about 90 per cent. are limited to the left side alone, nearly 10 per cent. show involvement of both sides, usually much more marked on the left, and less than 1 per cent. are limited to the right side. Right-sided varicoceles may be the result of some intra-abdominal lesion on the right side, as a tumor of the kidney, interfering with the return circulation. In the rare cases in which a right-sided varicocele is found, such a possible cause should be sought for. Many theories have been launched to account for the notable frequency of varicocele of the left side as compared to the right side. The most plausible suggestion is the anatomic differences between the right and left spermatic veins.

As already noted in discussing the surgical anatomy of this region, the right spermatic veins empty obliquely into the vena cava and the left at right angles into the renal veins. It seems to me that more important than this is the probable intermittent obstruction of the left spermatic veins by the now empty and now filled sigmoid flexure, which rests upon it. In support of this view is the clinical observation that individuals who suffer from constipation (*i. e.*, an overloaded sigmoid) are the most frequent sufferers from varicocele. The disease is developed in the period from puberty to the thirty-fifth year, the period of the greatest sexual activity. About 18 per cent. occur before the age of fifteen, 55 per cent. from the fifteenth to the twenty-fifth year, and 26 per cent. from the twenty-sixth to the thirty-fifth year. The veins are dilated and elongated and the vein walls thickened. In cases of long standing the testicle is soft and flabby and smaller than normal. The most important etiologic factors seem to be a hereditary predisposition to such vein lesions, chronic constipation, and bad sexual hygiene, including possibly both the extremes of ungratified sexual desire and sexual excess.

The **diagnosis** is made from the clinical picture. The scrotum is lax and the left side hangs down lower than the right (Fig. 332). There is irregular swelling, which, in well-marked cases, can be seen extending from the testicle and which can be felt to extend from the bottom of the scrotum to the external ring. On palpating this swelling it feels like a mass consisting of cells of distended veins. This has been compared to a mass of angle worms. When the patient assumes the recumbent position the veins empty themselves and the swelling disappears. On coughing in the recumbent position no impulse can be felt, but in large varicoceles a distinct impulse can often be felt on coughing when the patient is in the erect position, and because of this fact the mistake of diagnosticating these cases as hernia is often made.

Not infrequently a patient comes into the clinic wearing a truss, and sometimes stating that he obtained some comfort from it, and yet examination makes clear that the trouble is a large uncomplicated varicocele. Large varicoceles often seem to cause atrophy of the testis. The

symptoms complained of in varicocele are pain, both neuralgic and dragging in character, and sense of weight—all of which are relieved by lying down.

The nervous symptoms and the mental symptoms are often more important than the actual disability produced by the disease. Patients are apt to complain of mental depression, sexual weakness, and loss of memory, and they are inclined to attribute almost every ache or pain from which they may suffer to their varicocele. Advantage is taken by the advertising charlatan and by unscrupulous medical men of this morbid introspection, and many young men suffering from bad sexual hygiene are informed that they have a varicocele which must be operated upon, when in reality they have no varicocele at all, or such a trivial one that no operation is indicated. Varicocele of limited degree may disappear with advancing age and with the diminution of sexual activity.

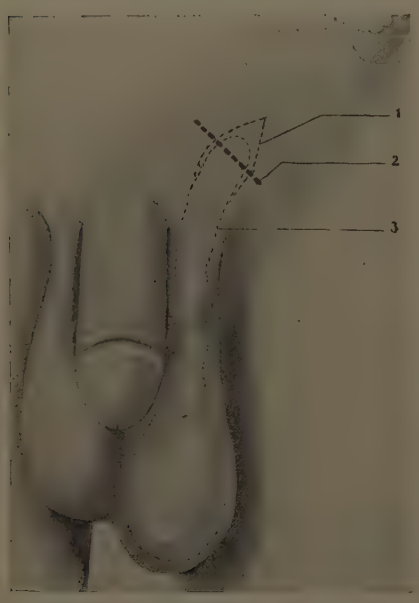

FIG. 332.—INCISION FOR VARICOCELE OPERATION.

Treatment.—The treatment of varicocele should be divided into palliative and radical or operative. It is obvious that if 25 per cent. of active men (as Senn has found of young men at the recruiting age for military service) suffer from some degree of varicocele, no such enormous number as this percentage represents require radical surgical treatment.

In the mild case proper sexual hygiene, means to prevent habitual constipation, and a cold sponge-bath each morning are usually sufficient to make the patient comfortable and prevent any serious result from the lesion. In those in which the enlargement is of moderate degree these measures, with the addition of a proper supporter, worn when the patient is on his feet, will suffice. In the cases in which the enlargement is of marked degree and in which the above measures do not control the symptoms, especially if there seems to be danger of atrophy of the testis, and in those cases in which the nervous and mental symptoms cannot be eliminated by a clear presentation of the facts to the patient, an operation may be indicated or even demanded.

Operative Treatment.—The operative treatment of varicocele can be divided into (*a*) the radical removal of the enlarged spermatic veins and (*b*) the abbreviation of the scrotum with the idea of making of it a permanent suspensory bandage, which will furnish an elastic support for the veins, just as does a rubber bandage or stocking for varicose veins

of the lower extremity. This last procedure is now seldom resorted to except as an accessory step to the radical removal of the veins in cases of great length and laxity of the scrotum.

Operative Technic.—The operation of exposing the veins through an incision in the scrotum, as is usually described in text-books, should never be done. A far better technic is one which I have devised, the steps of which are as follows. The patient is prepared for an aseptic operation, as for hernia, by shaving the pubis and scrotum and cleaning the field of operation with soap and water and alcohol. A general anesthetic, as ether or chloroform, may be employed, but the operation can readily be done under nitrous oxid gas or with cocain infiltration (1 : 1000 in normal salt solution). The latter is much to be preferred if the technic is well understood and carried out.

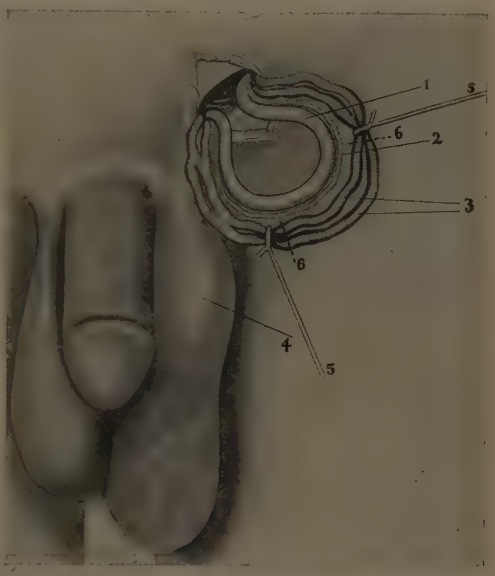

FIG. 333.—VARICOCELE OPERATION.
Ligation of the spermatic veins: 1, Vas deferens; 2, spermatic artery; 3, spermatic veins; 4, testicle drawn up; 5, catgut ligatures; 6, point of resection.

An incision one inch long is made transversely just below the external ring (Fig. 332). The skin and superficial fascia are infiltrated with the cocain solution, one hundred drops of which represents but one-tenth of a grain of cocain, and this amount is more than sufficient for the entire operation and is perfectly safe. The skin and superficial fascia are retracted with a pair of small retractors. The cord, covered by the intercolumnar fascia, the cremasteric fascia, and the infundibuliform fascia, is now exposed. These layers are infiltrated with twenty drops of the cocain.

As the cocain solution is injected into the areolar tissues surrounding the cord these tissues are ballooned up into view. They are seized by two dissecting forceps and divided parallel to the cord. The cord is now lifted up and drawn out of the wound on a Kocher dissector. The coverings of the cord must be fully divided in order to expose the vessels and the vas.

The vas and its vessels, both veins and artery, are separated from the spermatic vessels. About two inches of the spermatic vessels are now separated from the vas and its vessels by blunt dissection. If the spermatic artery can be recognized, it should be avoided and not included in the ligature. Very frequently it is included, and apparently without

doing any damage to the testis or interfering with its function. About two inches of the veins are included between two catgut ligatures (Fig. 333). The portion between the ligatures is now resected and the ends of the ligatures are tied, shortening somewhat the cord (Fig. 334). The small external incision is closed with horsehair sutures and sealed with collodion. The patient is kept in the recumbent position for a week and is required to wear a snug-fitting suspensory bandage for from six to eight weeks after the operation. The advantages of this technic over the older plans are very marked. The incision is small and yet the entire spermatic cord, if desired, can be brought into view.

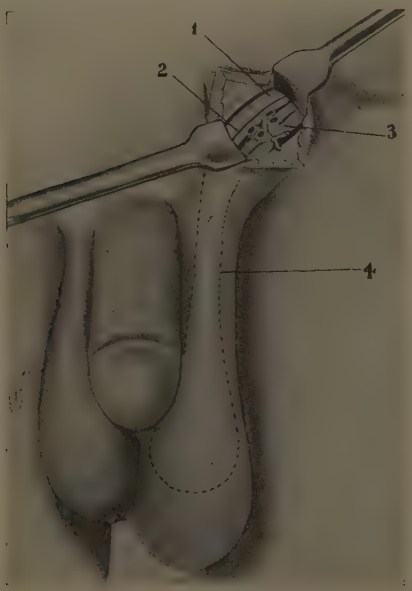

FIG. 334.—VARIOCELE OPERATION.

Ligatures tied after resection of spermatic veins: 1, Vas deferens; 2, spermatic artery; 3, spermatic veins; 4, outline of testicle and cord.

It is much easier to insure asepsis with the incision over the external ring than when it is placed in the tissues of the scrotum. It is much more comfortable to the patient to have the incision in the immovable tissues at this point than in the changing tissues of the scrotum. It is much easier to avoid the development of a hematoma in the scrotum by the method which I suggest than by the older methods. The cocain method of anesthesia, if properly employed, eliminates the dangers and dread which come with a general anesthetic, and if the technic is well carried out, the tissues gently handled, and the operation not hurried, it carries with it less discomfort than the filling of an ordinary tooth.

FIG. 335.—EXCISION OF THE SCROTUM AT RIGHT ANGLES WITH RAPHÉ FOR VARICOCELE (Hartmann).

Retention stitches applied; one pair of forceps removed and interrupted suturing begun.

If the scrotum is unusually long and lax, it may be abbreviated by clamping it off with a curved, fenestrated gastro-enterostomy clamp, introducing mattress sutures in the opening in the blades and tying these before the redundant portion beyond the clamps is removed. The clamp can be applied transversely, or better

possibly sagittally, as suggested by E. Wyllys Andrews. If this last-mentioned plan is employed, the scar takes the place of the medium raphé and is not noticeable. Fig. 335 shows abbreviation of the scrotum.

The results of varicocele operations under modern technic are excellent; the dangers are very small under asepsis and local anesthesia. A cure, as far as the real discomforts resulting from the enlarged veins are concerned, can almost always be obtained. The mental distress resulting from the real discomforts of the condition and the worry about the visible existence of the lesion as a rule disappear. In some neurotics, in which the varicocele is but an incident and not a cause of the neurosis, little good can be hoped for, beyond that obtained by the suggestion.

INJURIES, DISLOCATION, AND TORSION OF TESTIS.

Injuries.—Subcutaneous injuries of the testicle occur from blows of the fist, kicks, injuries received in games such as base-ball, foot-ball, gymnastics, horseback-riding, etc., or, without any apparent, direct injury, from great muscular effort. The injury is a peculiarly painful one and often accompanied by a severe degree of general symptoms compared with the extent of the local injury. Nausea, vomiting, and great weakness are common. Fainting and evidences of extreme shock occur in severe cases. Even fatal shock has been reported from contusion of the testis and yet nothing more than slight local hemorrhage has been found post mortem.

As a result of the injury more or less extravasation of blood and swelling, especially of the epididymis, may appear. The clinical picture is essentially that of an orchitis or an epididymitis of traumatic origin. The treatment is rest and a suspensory bandage.

Dislocation.—As the result of blunt force a singular accident is occasionally noted, *i. e.*, dislocation of the testicle up into the inguinal region, on the anterior surface of the thigh, or down into the perineum. Usually the dislocated organ can be readily reduced. Unless reduced the testicle may remain permanently in its dislocated position, becoming bound down by new connective tissue, which will prevent its reduction except by open operation. These cases are not to be confounded with kyrptorchidism. I have seen several cases in which the story was told by the patient of having had two testicles, but that owing to some injury one slipped into the abdomen, and yet upon operation I have found definite evidence of undescended testis, which had never been in the scrotum. It is a common failing of people to deny congenital malformations.

Abnormal Movability.—A few cases are found in which the testicle is very movable, so that it can be pushed up on the groin or even into the inguinal canal. The condition is due to the existence of a large pouch of peritoneum filling the scrotum and extending up on the groin and into the canal, and in this pouch the testicle hangs suspended. It is in this class of cases, as well as in undescended testis, that we are apt to find occurring the accident known as torsion of the cord (Fig. 336).

The torsion occurs suddenly after an injury or some violent muscular

exertion, and is accompanied with much the same symptoms as a strangulated hernia (severe pain, nausea, vomiting, and evidences of shock). Following this, there develops swelling in the scrotum, thrombosis of the spermatic veins, and, where the circulation is entirely cut off, necrosis of the testis. This accident occurs in undescended testis more frequently than in organs situated in their normal position.

It is difficult to differentiate this condition from strangulated hernia. Both of course demand immediate operative relief. If on operation the testicle is found necrotic, its blood-supply being entirely cut off, the organ should be removed. If operated upon early and the circulation is found not to be entirely cut off, the torsion should be untwisted and the testicle fixed by buried stitches so that the accident cannot recur.

Stab wounds, gunshot wounds, lacerated wounds, incised wounds, etc., of the testis occur, and are to be treated on general surgical principles. If possible, the injury is to be repaired with fine catgut stitches passed through the tunica albuginea. These prevent the prolapse of the soft secreting tissue of the organs.

FIG. 336.—TORSION OF THE SPERMATIC CORD WITH ACUTE GANGRENE OF THE TESTICLE (after Cohen).

ACUTE INFLAMMATIONS OF THE TESTIS AND EPIDIDYMIS.

In addition to the so-called traumatic epididymitis and orchitis (terms which are applied to the acute reaction with swelling and pain which follows injury to these organs, and which conditions have already been described under that head), there are recognized two distinct forms of epididymitis and orchitis depending upon infection with micro-organisms. There is a urethral form and a metastatic form.

The urethral form is much the more common and is due to acute inflammation of the urethra extending along the vas to the epididymis or to the testis. The germ usually is the gonococcus; any pyogenic micro-organism, however, may be the cause. About 20 per cent. of gonorrheal attacks are complicated with an involvement of the epididymis. The testis is involved in but a small percentage of the cases. The introduction into the urethra of instruments carrying various germs may lead to urethritis, which may extend along the vas to the testicle, or the traumatism of an already infected urethra, even with clean instruments, may lead to the lighting up of a latent gonorrheal or other inflammatory process, which may extend to the testis. The frequent use of a catheter in cases of enlarged prostate is responsible for many cases.

The second form is metastatic inflammation of the epididymis and testis proper, in which the germs are brought to these organs through the circulation and find there favorable conditions for their lodgment and

development with resulting inflammation. Mumps and typhoid fever are the diseases in which the metastatic form chiefly occurs. Occasionally it is met with in other acute infectious diseases, as grip, variola, acute articular rheumatism, etc. In the metastatic form the testicle proper is much more often the site of the inflammation than is the epididymis.

In acute epididymitis the organ swells to a large size so that it becomes larger than the testis proper. The entire epididymis may be involved equally or the tail or head may be the principal seat of enlargement (Fig. 337).

Symptoms.—The local symptoms are pain, swelling, tenderness of the testis with some edema of the scrotum, and in many cases an acute hydrocele. The general symptoms (chill, fever, and weakness) may be slight, but are sometimes marked. The duration of the acute symptoms varies from one to two weeks. The pain, swelling, and tenderness gradually disappear, leaving for some time, as a rule, a hard lump in the head

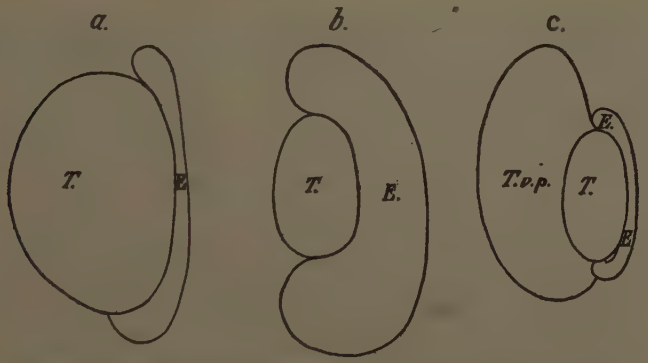

FIG. 337.—SCHEMATIC REPRESENTATION OF SCROTAL TUMORS (Koenig).
a, In acute orchitis; *b*, in acute epididymitis; *c*, in periorchitis; *T*, testis; *E*, epididymis; *T.v.p*, tunica vaginalis propria.

or tail or both of the epididymis, which lump may disappear or persist permanently. This fact is of the greatest importance, as it has been found that where this induration persists the canal of the epididymis is permanently blocked, so that spermatozoa can no longer be furnished by the involved organ. If this condition is bilateral, the individual is sterile. Double epididymitis is the most common cause of sterility in the male.

Treatment.—The treatment in the acute stage is rest in the recumbent position with the support of the testicles well up over the abdomen by means of a triangular bandage. The triangular bandage (Fig. 338) is the most important measure of treatment which can be employed in acute inflammations of the testis. It must be properly put on. It consists of a triangle of silk, muslin, or gauze about two feet long to which is fastened with a safety-pin a double piece of 2-inch roller bandage sufficiently long (about two feet) to act as perineal straps. A strip of 3-inch bandage is tied around the waist. The long side of the triangular bandage, with the perineal straps pinned to its center, is now placed under

the scrotum. The perineal straps are brought around the thighs and fastened to the bandage around the waist. The long corners of the triangle are now fastened to the waist bandage, and lastly the central angle of muslin is pinned to the waist bandage with a safety-pin. This central angle can be unfastened when the patient desires to urinate, and can then be readjusted by him.

The properly adjusted triangular bandage furnishes the patient much more comfort than any other form of treatment; in fact, other treatment can well be dispensed with. Hot fomentations or ice-bags may be used if they seem grateful. Applications of iodin, tobacco, etc., are best omitted.

After the acute stage a well-fitting suspensory can be worn until all evidence of the disease has disappeared. If the induration and swelling persist for weeks, they may be removed by strapping the testicle with adhesive straps. Before doing this, the scrotum should be shaved, and

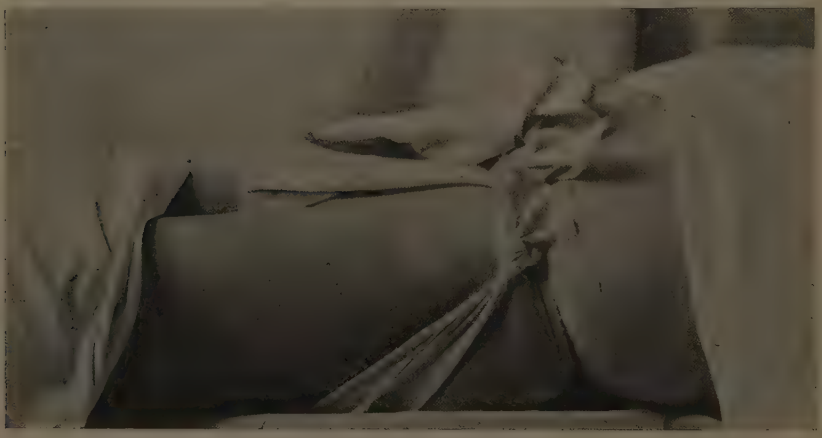

FIG. 338.—TRIANGULAR BANDAGE.

the half of the scrotum over the diseased gland is then grasped just above the testicle and encircled with an adhesive strip, half an inch wide and six to eight inches long. This is put on sufficiently tight to hold the testis below the strap; then, with similar strips applied in both a circular and vertical way, the entire half of the scrotum is covered with adhesive plaster. This often gives great relief and is followed by a rapid reduction in the swelling. The strapping should be repeated every two days until the swelling has disappeared.

In a few cases the acute inflammation becomes suppurative and demands incision and drainage. The evidence of the suppurative process is usually sufficiently clear (chills, persistence of fever, an increase in severity of the local symptoms). If the organ is riddled with abscesses and the suppurative process becomes a chronic one associated with fistulas, castration may be indicated.

CHRONIC INFLAMMATION OF THE TESTICLE AND EPIDIDYMIS.

Tuberculosis.—Tuberculosis of the epididymis and testicle is, next to gonorrheal inflammation, the most common disease of these organs. The disease, in the overwhelming majority of cases, begins in the epididymis and extends later, as a rule, to the testis proper (Fig. 339). In only a small percentage of cases does it attack the testicle before the epididymis is affected. The tubercle bacilli gain access to the epididymis through the circulation. An ascending tuberculous inflammation from the urethra, acquired in intercourse with a woman suffering with a tuberculous lesion of the genitals, was regarded at one time as the cause in some cases. This theory of infection is now generally discarded. In a large percentage of individuals with tuberculous infection of the testis a preceding tuberculous lesion can be determined, and it is probable that in most of the remaining cases a tuberculous focus does exist (as a bronchial or cervical gland from which the bacilli escape into the circulation and find lodgment and favorable breeding-ground in the epididymis). It must be only in a small percentage of the cases that the bacilli gain access to the body, through either the alimentary tract or the respiratory tract, and find their way immediately into the circulation and are carried to the testis and produce here a true primary tuberculosis of this organ.

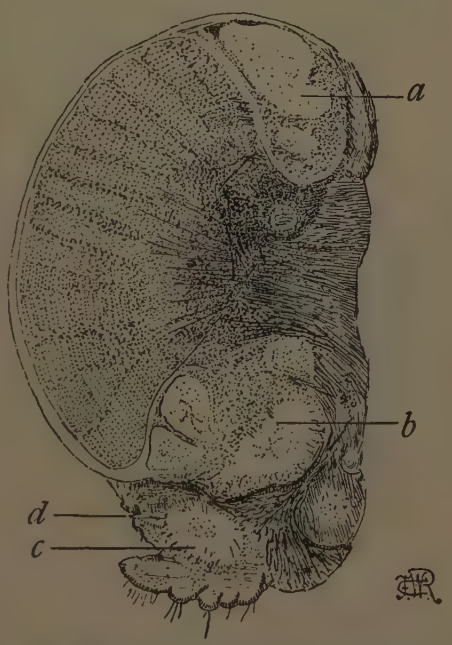

FIG. 339.—TUBERCULOSIS OF THE EPIDIDYMIS EXTENDING TO THE TESTICLE BY CONTINUITY OF THE TUBERCULOUS PROCESS (Senn).

Factors which favor the lodgment of the tubercle bacilli in the epididymis are trauma, loss of local resisting power due to previous disease (as a gonorrheal epididymitis), and the congestion of active sexual function. It is to be observed that the lesion is one limited largely to the period of active sexual life, from fifteen to fifty.

It was for a time believed by some that the testicle was the organ first involved in genito-urinary tuberculosis, and that from this point of infection the vas, the seminal vesicles and prostate, and bladder, ureter, and kidneys later became diseased in an ascending tuberculosis. Others taught that the kidney was first diseased and that the ureter, bladder, prostate, vas, and testicle were involved in a descending process.

It is today accepted as a demonstrated fact that the so-called primary

tuberculosis of the genito-urinary organs can begin at a number of points (kidney, prostate, and testis, and in the female the tubes and ovary), and that the course taken in the extensions of the process to the other organs is certainly, as a rule, with and not against the lymph-stream.

Tuberculosis of the epididymis begins usually as a subacute process, sometimes as a silent process without any symptoms attracting the attention of the patient, and occasionally as rather an acute process, simulating closely gonorrheal epididymitis. In these acute cases there is often mixed infection. A hard lump develops in the head or tail of the epididymis, and within some weeks it extends along the vas, producing a nodular thickening of this structure. The tunica vaginalis is often involved and becomes more or less distended with fluid (a symptomatic hydrocele). As a rule, within a few weeks or months the process extends to the testis proper and to the surrounding structures of the scrotum. The scrotum becomes fixed to the testis by the extension of the tuberculous process and a fistula forms through which the caseous material of the focus in the epididymis is discharged. Thus the process frequently goes on to apparent cure. Sometimes, in extensive involvement of both the testicle and the scrotum, the tuberculous granulation tissue may project as a fungous mass (Fig. 340).

FIG. 340.—HERNIA OF THE TESTICLE FOLLOWING PRIMARY TUBERCULOSIS OF THE SCROTUM (Duplay and Reclus).

The disease may extend along the vas to the seminal vesicles, prostate, and bladder, and to the other testicle. The disease usually destroys the function of the organ involved. If both testicles are diseased, the individual is sterile. Tuberculosis, next to gonorrheal disease of the epididymis, is the most common cause of sterility. The diagnosis is, as a rule, not difficult. The subacute history, the marked involvement of the epididymis, the nodular thickening of the vas, the possible finding of evidences of the same process in the seminal vesicles by rectal examination, the presence of fistulas when they exist, the age of the patient, the history of tuberculosis in the family, etc., as a rule make the clinical diagnosis sufficiently clear.

Treatment.—The treatment of tuberculosis of the testis is a matter which is much in dispute. Some surgeons are in favor of a general hygienic treatment and oppose operation. Others believe that early castration is indicated, and still others, especially the French surgeons, have strongly urged resection of the involved epididymis with retention of the testicle.

Upon an analysis of a considerable number of cases it seems that the following rules of treatment should be adopted. In cases of tuberculosis of the testicle in individuals suffering from other evident tuberculosis, the treatment should be the open air and general hygienic treatment of tuberculosis, and no operation should be performed unless the diseased testicle is a source of discomfort to the patient and is affecting the general health; in which events a rapid castration under nitrous oxid gas should be done. In cases in which the disease of the testicle is the only apparent point of infection a wide exploratory operation should be performed, exposing fully the entire extent of the lesion. If the disease is distinctly limited to the epididymis this structure, with the vas, should be removed. If the testicle is at all involved, the testicle and cord as high as possible should be completely removed.

Cures after single castration are obtained in about 40 per cent. of cases; after double castration in about 50 per cent. of cases. The remainder die of tuberculosis of the genito-urinary organs or of general tuberculosis. In the treatment of tuberculosis of the testis too much stress cannot be placed upon the importance of the outdoor fresh air and building up treatment, which is of so much benefit in lung tuberculosis. This alone will cure many cases, and in the cases operated upon, it should always be carried out.

Fig. 341.— Intratesticular Gumma with Sclerosis of Surrounding Tissue (Duplay and Reclus).

Syphilis.—Syphilis of the testis may occur in children, the result of inherited syphilis, or in adults, the result of acquired syphilis. In the adult it is a late tertiary manifestation of the disease. Syphilis of the testis affects in almost all cases the testicle proper, differing sharply in this regard from tuberculosis, which usually attacks the epididymis first. This fact is of much importance in making the differential diagnosis between the two diseases. Syphilis of the testis occurs in two forms: as a diffuse thickening of the fibrous tissues of the testis, which may go on to a complete destruction of the secreting tissue, or as a gumma beginning more or less centrally, extending in all directions (Fig. 341), and leading, if not checked by treatment, to a destruction of the testis.

The disease runs a painless course; the attention of the patient is called to the gradual increase in size of the affected organ. This may become so large and heavy as to produce dragging pains along the cord. A symptomatic hydrocele is often present. The gumma may soften and be discharged through a fistula in the scrotum (Fig. 342). When at all extensive, the syphilitic process destroys the function of the testicle. When both testicles are thus involved, sterility is the result.

The **diagnosis** is made from the history of the case, from the existence of other evidences of syphilis, the chronic, painless course, the limitation

of the process to the testis proper, and the hard, elastic feel on palpation. The differential diagnosis must be made especially between syphilis, tuberculosis, and tumor. Not infrequently iodid of potassium must be employed as an aid to diagnosis as well as a means of treatment. It should be given in 10-grain doses three times a day, the dose being gradually increased from 1 grain to 5 grains a day, depending upon how well it is borne. The increase is continued progressively until the patient is taking from 100 to 300 grains daily.

The syphilitic swelling, as a general thing, rapidly melts away under this treatment. In long-standing cases it is probable that the function of the organ is usually lost. After the swelling has disappeared a mercurial course should be given either by inunction or hypodermic injection.

FIG. 342.—ULCERATING GUMMA OF THE LEFT TESTICLE (Saint-Louis, Le Dentu).

The other causes of chronic inflammation, such as leprosy and actinomycosis, seldom involve the testis. I have met with one case of actinomycosis of the testis in a case of lung actinomycosis. In this case, of course, the testicle became infected through the circulation. An abscess involving the epididymis was opened and drained and the disease of the testicle cleared up under large doses of the iodid of potassium.

SPERMATOCELES; RETENTION CYSTS OF THE TESTICLE AND EPIDIDYMIS.

Spermatoceles are cysts containing fluid in which spermatozoa are found. They are situated most frequently in the neighborhood of the head of the epididymis, and are often placed between this and the testis proper. They vary in size from the size of a plum to the size of an egg, seldom larger, although a few cases are reported which contained a pint or more of fluid.

It is believed that they originate in some of the fetal remains about the testicle and epididymis. These fetal remains are the so-called appendices of the epididymis and testicle (the hydatids of Morgagni, both the sessile and pedunculated; the paradidymis or organ of Giraldés and the vas aberrans and the vas du rete). From any of these fetal structures a retention cyst can develop. As a rule, such cysts contain spermatozoa, although these cells may be absent.

The diagnosis is made from the position of the cysts near the junction

of the epididymis and testis and independent of both. Usually one can make out all three structures—cyst, testis, and epididymis. The development is slow and painless. The lesion is one of little moment, unless it attains a large size.

As possible etiologic factors are to be mentioned trauma and inflammatory lesions, such as gonorrheal inflammation of the testis. Sometimes calcareous or even bony infiltration of the cyst wall occurs. The differential diagnosis must be made from hydrocele and neoplasm. Its size, shape, and location usually enable one to distinguish it from hydroceles. The finding of spermatozoa in the fluid withdrawn can no longer be regarded as sufficient to establish a diagnosis, as it has been found that spermatozoa are present in a certain proportion of hydroceles.

The sac may be intravaginal (Fig. 343), but in most cases it is outside of the tunica vaginalis. If of small size (as large as a cherry or small plum) and giving rise to no discomfort and not increasing in size, it may be let alone.

The withdrawal of the fluid with a needle and an aspirating syringe is occasionally followed by cure, as is also the injection of a few drops of carbolic acid into the sac after the removal of the fluid. As a rule, however, the fluid reaccumulates. A radical cure can only be assured by the complete removal of the sac. This can, as a rule, be easily accomplished. An immediate closure of the wound should be made.

FIG. 343.—SPERMATOCELE (Kocher).

TUMORS OF THE TESTICLE.

Almost every variety of neoplasm may occur in the testicle. Tumors of the testicle are not very common. The benign connective tissue tumors (the lipoma, fibroma, enchondroma, and osteoma) are seldom encountered. Lipomata occur within the scrotum not infrequently, but as a rule do not involve the testis, but do involve the cord. It is not uncommon to find a large lipomatous mass around the cord in connection with a hernial sac.

The malignant connective-tissue tumors (the sarcomata) are fairly common. They occur in children and in early adult life. They are believed to occur more frequently in undescended testicles than in those normally placed. Either the testicle or the epididymis is the starting-point of the growth. The usual type is the small, round-celled, or spindle-celled sarcoma. Sometimes melanotic sarcomata occur. The course of sarcoma of the testis may be slow, but is, as a rule, rapid; the process extending up along the spermatic cord to the abdominal cavity. If let alone, the growth may break through the scrotal tissue and present a great fungous, malignant mass. The prognosis is bad. I have never seen a permanent cure, even after fairly early and complete castration.

Permanent cures, however, have been reported, and it is our duty to make a complete castration, with removal of the cord as high up as possible, in all patients who do not show any evidence of general sarcomatous disease. From our present knowledge I should advise, in the round and spindle-celled forms, an extended treatment with Coley's mixed toxins of bacillus erysipelas and micrococcus prodigiosus, as a possible means of preventing recurrence of the tumor after castration.

The majority of malignant tumors of the testis are carcinomata. They develop usually in the tissue of the testicle proper. They may be of the medullary type or scirrhus. The cancerous invasion extends early to the inguinal lymph-glands and the retroperitoneal glands. The diagnosis is made from the hardness and irregularity of the swelling, the absence of acute symptoms, and by excluding, when possible, syphilis. In case of doubt an exploratory incision into the swelling should be made. When the diagnosis is determined on, the treatment should be the most radical castration with high removal of the cord and extirpation of the inguinal lymph-glands. The prognosis is bad. A few permanent cures have been reported, but they are rare exceptions to the rule. It is quite certain that earlier operations would give a much better outlook.

FIG. 344.—A DERMOID OF THE TESTIS SHOWN IN SECTION (Museum Royal College of Surgeons, London).

Dermoid cysts and teratomata of the testicle occur just as in the ovary (Fig. 344). The tumor is one of early life, although it may not develop to a size sufficient to attract attention until puberty or later. The definite diagnosis cannot be made except by exploratory puncture or incision. The tumors are essentially benign, although they may become the site of sarcomatous or carcinomatous degeneration.

The treatment is removal of the growth and leaving the testicle if this is possible. The prognosis is favorable.

THE OPERATION OF CASTRATION.

The operation of castration, on both man and the lower animals, is one of the oldest of surgical procedures. It has a wide range of application. It may become necessary for extensive injury, gangrene, acute processes in which the organ is riddled with multiple abscesses, in chronic inflammations such as tuberculosis, and it is especially demanded in malignant disease.

The operation is one which can be rapidly done, and I have therefore of late years used nitrous oxid gas as the anesthetic of choice in these cases. An incision is made beginning over the external ring and extending down the scrotum for about three inches. This divides the skin and dartos. In cases where the skin is involved an elliptic incision including the diseased part is made. The testicle and cord with their coverings are then separated from the scrotal tissue. If the condition demanding castration is one in which the cord may be involved, as in tuberculosis or malignant disease, the inguinal canal should be split up and the cord ligated as high as possible before division. The ligation of the cord must be most thoroughly done. I have seen several serious hemorrhages after castration because of the slipping of the ligatures on the cord (Figs. 345 and 346).

It is well to transfix the cord at an avascular part and double ligate and even put on a second ligature around the suture cord for additional

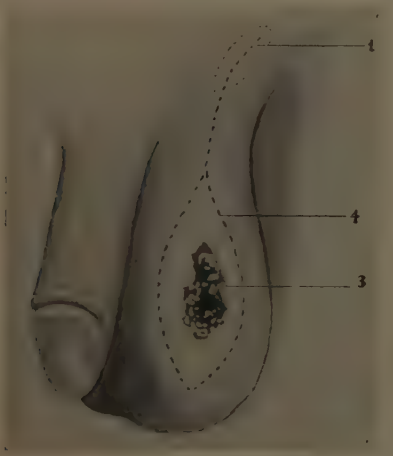

FIG. 345.—CASTRATION.
Line of incision.

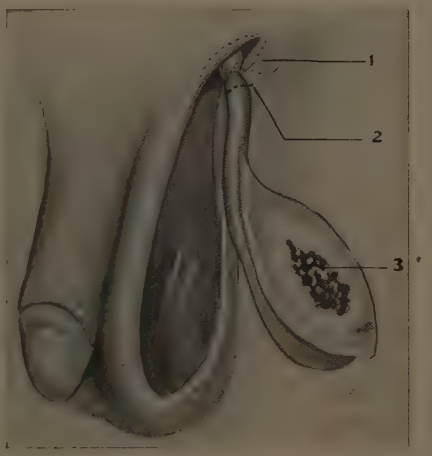

FIG. 346.—CASTRATION.
Ligation of cord.

safety. In the aseptic cases the wound is completely closed with the exception of a small drain of gutta-percha, which is removed at the end of twenty-four hours. In the infected cases thorough drainage must be provided.

Occasionally, sexual neurotics come to the surgeon and demand castration as a relief from their condition. I have known several cases in which surgeons have unfortunately consented to do this. Such operations as these are criminal and should under no circumstances be countenanced by the profession. The same should be said of the operation of resection of the vas in these individuals. These patients are afterward often sorry that the operations were performed and in some cases sue the surgeon for malpractice.

DISEASES OF THE SEMINAL VESICLES.

The seminal vesicles can be examined with the finger introduced into the rectum and carried up above the upper limits of the prostate gland. In normal cases the seminal vesicles are so soft and compressible that they cannot be distinctly outlined, but when these structures are infiltrated

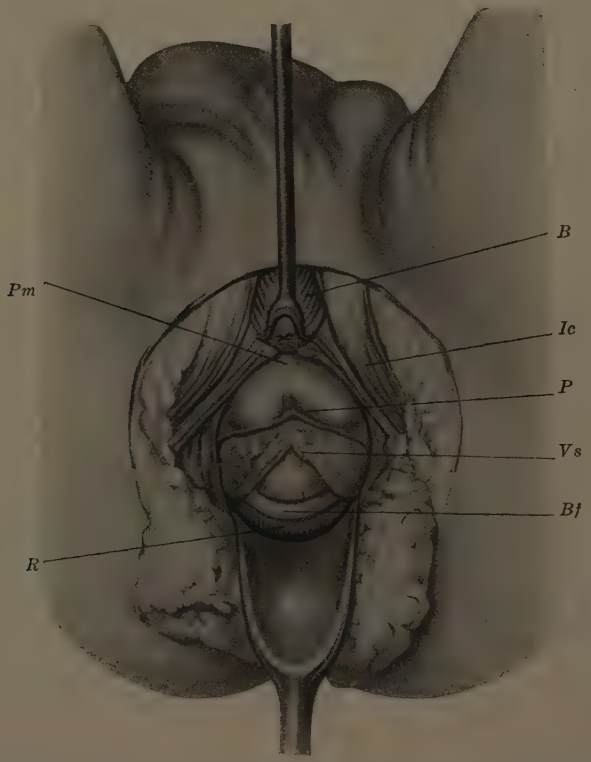

FIG. 347.—EXPOSURE OF THE PROSTATE GLAND, THE SEMINAL VESICLES, ETC., BY MEANS OF A PRERECTAL FLAP INCISION BY THE METHOD OF O. ZUCKERKANDL (Zuckerkandl).

Above, the wound is bounded by the bulb of the urethra (*B*), with the bulbocavernosus muscle, and by the cavernous bodies of the penis with the ischiocavernosus muscle (*Ic*). Between the bulb and the prostate a portion of the membranous part of the urethra (*Pm*) is visible. The detachment of the rectum has been effected in maximum degree. The prostate gland (*P*), the seminal vesicles (*Vs*), the extraperitoneal portion of the posterior wall of the bladder and, finally, at the bottom of the wound, the line of reflection of the peritoneum (*Bf*) from the bladder upon the rectum (*R*) are exposed to view.

with disease, as tuberculosis or carcinoma or acute inflammation and abscess, they can be easily felt.

By **massage** the contents of the seminal vesicles can be forced into the urethra or bladder and an examination be made to determine the character of the fluid. Injuries of the seminal vesicles are rare on account of the protected position of the structures. Injury may occur in gunshot wounds and fractures of the pelvis, but is more frequently seen as an accident in operations on the bladder, prostate, and rectum.

Inflammation of the seminal vesicles of an acute character is usually a gonorrheal or a mixed infection resulting from an extension of inflammation from the urethra. It is probable that a certain degree of involvement is not uncommon in gonorrheal inflammation of the deep urethra. It is difficult to differentiate the symptoms produced by a mild spermatocystitis from the symptoms resulting from an involvement of the deep urethra and prostate. Examining the expressed contents of the vesicles after thoroughly cleaning the urethra may be of service in establishing a diagnosis.

The appearance of blood and pus in the ejaculations points strongly to an involvement of the seminal vesicles. The mild cases recover without any special therapy. The subacute may be aided by gently emptying the vesicles with an instrument made especially for the purpose (a smooth metal bulb mounted on a handle, which is introduced into the rectum and drawn from above downward over the vesicles, expressing their contents). This stripping should be repeated every other day. In acute cases which go on to abscess formation the abscess should be opened through the rectum under anesthesia after wide dilatation of the sphincter so that the point of fluctuation can be well reached or through the curved transverse perineal incision of Dittel and Zuckerkandl (Fig. 347). This, however, is a formidable operation and should not be selected, if the simpler method of drainage through the rectum will suffice.

FIG. 348.—TUBERCULOSIS OF THE SEMINAL VESICLES AND THE LOWEST PORTION OF THE VAS DEFERENS (Senn).

Calculi of the seminal vesicles are occasionally found, usually at post mortem. Often calculi give rise to no symptoms. Cases have been reported, however, where the calculi have produced obstructive symptoms—pain and seminal colic. These stones are, as a rule, soft, and they can be crushed between a sound introduced into the urethra and a finger in the rectum.

Tuberculosis of the seminal vesicles is the disease which most frequently brings these organs to the attention of the surgeon. It is commonly found associated with tuberculosis of the testicle, the disease having extended to the vesicles from the testicle along the vas. Tuber-

culosis of the seminal vesicles may result from an extension to them of a primary tuberculosis of the prostate. Primary tuberculosis of the seminal vesicles is not regarded as a probable lesion. In tuberculosis of the seminal vesicles the nodular thickening produced by the disease can be felt by rectal examination (Fig. 348).

It has been found that in some cases tuberculosis of the seminal vesicles, secondary to tuberculosis of the testicles, goes on to cure after castration has removed the primary focus.

The operative removal of the seminal vesicles has not been very successful and should not be undertaken unless it can be shown that the tuberculous lesion is limited to the vesicles and other structures, which can be removed. If an operation is decided upon, the Dittel-Zuckerkandl incision should be employed. (See Fig. 347.)

The seminal vesicles are frequently involved in carcinoma of the prostate and of the rectum, but are seldom the seat of primary malignant disease.

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CHAPTER LXII.

SURGERY OF THE INTESTINES, BUT EXCLUDING THE APPENDIX, THE RECTUM, AND THE ANUS. SURGERY OF THE OMENTUM AND THE MESENTERY.

By Weller Van Hook, M.D., and Allen B. Kanavel, M.D.,
CHICAGO.

ANATOMIC CONSIDERATIONS.

The intestinal tract presents extremely complex anatomic relations, which the student of abdominal surgery must master before undertaking practical work. Originally a short and simple structure in the embryo, it elongates, acquires glands and other accessory organs, alters in form and diameter, for a time protrudes from the incomplete abdominal cavity, and at last returns to it, continually changing form, until at last in the new-born child it attains peculiarities of relationship one could not have dreamed of when considering its simple anlage. The peculiarities of its normal anatomy have occupied the greatest anatomic minds, and a rich mass of material upon the subject is now available in all text-books.

A multitude of variations from the usual course of development and final fixity of form are to be studied in their relation to the more recondite problems of surgery. These variations are particularly numerous with reference to the association of the bowel within its own covering of peritoneum and that of the other abdominal structures. In many ways these curious peritoneal associations are of surgical importance, constituting as they do agencies for the restraint of the intestines, or to permit them to swing freely about in the abdomen, and sometimes giving opportunity for the formation of artificial sacs, pockets, loops, and bands that may strangle the tube under unfavorable conditions.

When to the variations within normal limits are added those conditions which, though not due to what we ordinarily call diseases, are classed by anatomists and pathologists under the heads of anomalies and malformations, we see that the subject of intestinal anatomy is too extensive and important for consideration within the brief limits which can be allowed it in a surgical chapter.

It is only where these peculiarities become of frequent clinical importance that we shall discuss them. The student of the subject is urged seriously to preface his study of this important field of surgery by acquiring familiarity with the best text-books of anatomy.

The complications of the subject are heightened by the multiplicity of important functions performed by the bowel, considered from a surgical standpoint.

The *digestive function of the bowel* demands that a certain area of mucous membrane furnished with the different glands peculiar to it shall be provided in order that the successive changes through which the contents of the bowel must pass may be effected in an orderly way. The products of the activities of glands accessory to the tube may act in very various ways when surgical conditions arise. The digestive juices are irritant to a high degree when applied to surfaces unaccustomed to their action. Not only the ferments of the intestinal juices and their chemical compounds have an important effect under strange conditions of environment, but the bacterial flora of the bowel are also of the greatest importance in this respect.

The *peritoneal relations of the bowel* are of the highest importance, largely because of these actions upon it by the contents of the tube. In another chapter (Vol. III, p. 745) the weaknesses and the sources of strength of the peritoneum are shown. The marvelous resorptive power of the structures associated with the peritoneal sac are in alliance with the swift agglutinating action of the peritoneal covering of the intestine, which alone makes it possible for us to successfully suture the bowel, since it is only this agglutination which prevents the escape of the intestinal contents into and about the wound in the intestinal wall.

Of prime importance is the *motor function of the intestine*, which depends upon the patency of the tube and the functional activity of the smooth muscle-fibers in the intestinal coat.

The canalization of the tube is normally perfect. There are, to be sure, at different points, variations in the diameter of the bowel, as well as a complicated and interesting mechanism at the iliocecal valve, and we shall have occasion to touch here and there upon the interesting questions involved in the attachments of the intestine to the more fixed parts of the body.

No one can realize so distinctly as the practical surgeon the extraordinary adaptive power of the bowel under adverse conditions of fixation and diminution of caliber. The fluid and gaseous character of the intestinal contents, the slippery, snake-like activities of the bowels, and the persistent patience with which resistances to the motor function are met by the tube all tend to nullify the effect of mechanical difficulties. The most astonishing adhesions, the most extraordinary contractions of the mesentery, the most surprising diminutions of caliber, are frequently overcome by these natural forces, aided frequently by the actual increase of muscular power brought about by hypertrophy, so that upon inspection one is often astonished to find that the conditions present have not resulted long ago in pathologic disaster.

THE OMENTUM.

Torsion of the great omentum with sufficient constriction of the blood-vessels to produce gangrene occurs in rare instances. The symptoms are much like those of intestinal obstruction. The clearest ideas upon this subject may be gained by a study of illustrative cases.

Litthauer[1] reports Bayers' case of torsion and incarceration of the omentum. A woman, aged fifty-four, suffered for fifteen years with a left labial hernia. She wore a truss only at times. One day she felt pain in the hernia, followed the next day by swelling. An operation was performed, and upon opening the hernial sac omentum with distended veins appeared. With the finger in the ring more omentum was felt, and the incision of the abdominal walls was extended, whereupon the omentum was found to be repeatedly twisted on its axis. Its free tip coming into view, it was observed to be swollen, of a dark brown color, and nearly gangrenous. The omentum above the twist was ligated and removed and the woman recovered.

Comer and Pinches[2] have made a study of fifty-four cases of torsion of the great omentum, adding three cases of their own. The first of their cases was that of a woman of thirty-seven, who had been ill for ten days with pain in the right side. There was no constipation and the temperature was only slightly raised. No hernia was present. There had been previous, though slight, attacks of pain and discomfort. There was a tender mass in the right iliac fossa, extending to just above the umbilicus, which was dull on percussion and the outlines of which could not be clearly defined. Per vaginam and per rectum nothing abnormal was found, and appendicular abscess was diagnosticated. Upon opening the abdomen a rush of dark green odorless fluid, which had evidently been imprisoned under tension, followed. Inserting a finger, a cavity was entered, on the inner and anterior aspect of which was felt a mass harder than the other walls. As pus was not present, adhesions were broken down and a mass of omentum delivered. A twist was seen at the proximal end; the mass was ligatured and removed, and the patient recovered.

The second case was that of a man of forty-one who had had right reducible inguinal hernia for eighteen years. There had been previous attacks of pain in the hernia, which for some days had been irreducible, painful, and slowly enlarging. There was no sickness and the bowels were open. Previously there had been pain when the hernia came down and remained irreducible. Strangulated hernia was diagnosticated. Upon operation it was found that the sac contained an enormous mass of dark colored omentum. Traction on the mass easily withdrew it from the abdomen. The pedicle was found to be twisted, and after removal to consist of a large portion of omentum altered by chronic inflammation, adherent and divided into numerous lumps. The patient recovered.

The third case was a man of forty-five who had suffered from large right inguinal hernia of long standing, attacks of pain being increasingly severe for some time. At the lower part of the sac was a small loculus separated from the rest by an obvious constriction. Strangulated hernia was diagnosticated. Upon operation there was found to be no strangulation in either the upper or lower part of the sac. When the lower loculus was laid open it was seen to contain a small rounded mass of omentum, which was not adherent, but was twisted on its pedicle. The patient recovered.

The omentum is seldom the seat of primary disease. Nevertheless

in rare cases cysts of the same character as those occurring in the mesentery are encountered.

Much more frequently is the omentum affected by secondary disease, such as tuberculosis and carcinoma. In the former disease great masses of contracted inflamed omentum may simulate other intra-abdominal tumors.

Cyst.—A case of cysts of the omentum was reported by Rufus E. Fort.[3] The patient was a female child two and a half years of age, fairly well nourished, with no history of disease except two attacks of acute indigestion. Eighteen months previous to this time the mother had noticed an abdominal enlargement which had progressed until at the time of Fort's examination the abdomen had a circumference of 28 inches at the umbilicus. The general health and nutrition had been very good except that there was some dyspnea upon exertion. Examination showed the following physical signs: Great abdominal distention, prominence of the abdominal veins, and complete dullness on percussion over the whole abdomen. A decided wave of fluctuation could be obtained at any part of the abdomen. The pulse was 100; the temperature and the urine were normal.

The enormous abdominal distention indicated pressure upon the abdominal vessels, and seemed to call for relief. Five pints of dark bloody fluid were removed by aspiration. Five days later the abdomen was opened by a median incision from a point above the umbilicus downward. A dark glistening tumefaction appeared, looking like distended gangrenous intestine, which was delivered through the incision without rupture. It was found to be a collection of fluid in the folds of the great omentum, extending from under the pylorus on the right side along the greater curvature of the stomach to and including the folds of the gastrosplenic omentum. After ligating the attachments of the omentum the mass was removed. There were no adhesions.

The specimen showed the absence of a distinct capsule, the fluid being between the folds of the omentum. There was no fat in the omentum, but the blood-vessels were greatly dilated. The fluid had a specific gravity of 1007 and contained albumin and degenerated blood-cells.

Fort has collected twenty-one cases of this kind, his own making the twenty-second. Rokitansky states that perhaps all of these tumors are of lymphatic origin, and result either from dilatation of the lymph-vessels or from cystic degeneration of the lymph-nodes.

Two dermoid cysts of the omentum have been reported by Waldy and Spencer Wells.

Cysts of the omentum are seen most frequently in children under ten years of age, 50 per cent. being under ten, and 65 per cent. under twenty years of age. The congenital origin of the cysts is thus strongly suggested. Seventy-five per cent. of the cases occurred in females.

The congenital origin of these cysts is strongly supported by the case of Hearn, in which a boy of eight was afflicted with a fluctuating tumor at birth. This tumor decreased in size for some time, but later further

enlargement become apparent. The cyst was aspirated at four years of age, but upon its refilling it was removed by Hearn four years later.

The **symptoms** seldom lead to early discovery of the difficulty. Pain is not usually present, and, when present, seems due, as a rule, to digestive disturbances. Dyspnea has frequently been observed. No characteristic symptoms of these tumors have been described.

The **diagnosis** has never been accurately made before operation. Ascites, lipoma, aortic aneurism, hydatid cyst of the liver, pancreatic cyst, cyst of the urachus, tuberculous and encysted peritonitis have been wrongly diagnosticated.

Péan regards three points as of great importance in the diagnosis of omental tumor—superficial location, abnormal passive mobility with downward limitations, absence of functional disturbance; to which may be added the fact that respiration has little or no effect on the position of the tumor.

P. Matthews[4] cites the case of a boy eight years of age, admitted with vague abdominal pain, chiefly in the left side. With increasing abdominal distention the pain subsided. There was no history of any previous illness or of trauma and the family history was negative. The symptoms were dyspnea, abdominal tumefaction, distention of superficial veins, resistance to palpation being most marked in the center and just above the umbilicus. There was absolute dullness everywhere except in the flanks and the hypogastrium, where the note was tympanitic. Posture made no difference as to the limits of dullness. A well-marked fluid thrill was observed. The glands in the axillæ, groins, and supraclavicular triangle were palpable.

On tapping, 4 ounces of opaque red-brown fluid were withdrawn. The fluid was of alkaline reaction and had a specific gravity of 1.024. It did not coagulate on standing, but there was a heavy deposit of red blood-cells, with few leukocytes and endothelial cells, the supernatant fluid becoming green. An indistinct mass was palpable along the right side of the vertebral column. The abdomen refilled and the patient's general health began to fail. Tapping was repeated three times. The temperature was 102° to 103° F., accompanied by vomiting and abdominal pain.

Laparotomy was performed. When the cyst was tapped, it was found to lie entirely in front of the intestines and was slightly adherent to the parietal peritoneum in the midline below the umbilicus and in the right flank. These adhesions were separated and the cyst was found to be attached to a thick pedicle of omentum running up to the transverse colon. This pedicle was clamped and the cyst withdrawn from the abdomen entire. There was no vomiting and no rise of temperature after the operation. Microscopic examination showed it to consist of lymph-angiomatous tissue. The recovery was uninterrupted.

THE MESENTERY.

In penetrating wounds of the abdomen **injury to the mesentery** is one of the most common and serious lesions encountered. Its

consequences are important in proportion to the extent to which the integrity of the blood-supply is compromised. Hemorrhage from mesenteric vessels may be fatal. If a large mesenteric arterial branch is merely

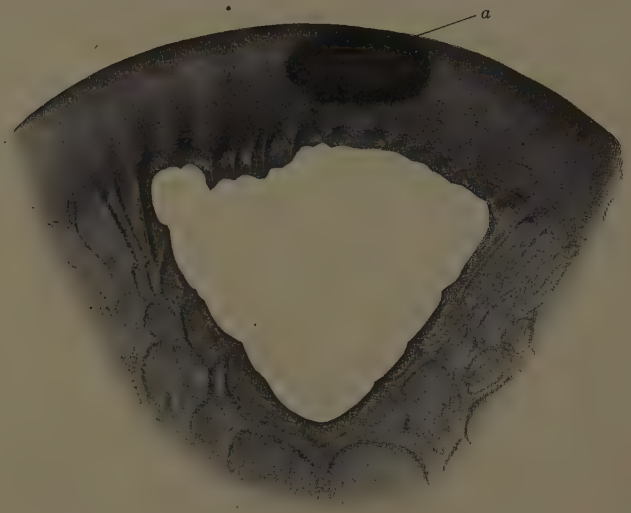

FIG. 349.—TRAUMA OF THE MESENTERY (Erdmann).
a, Gangrenous area.

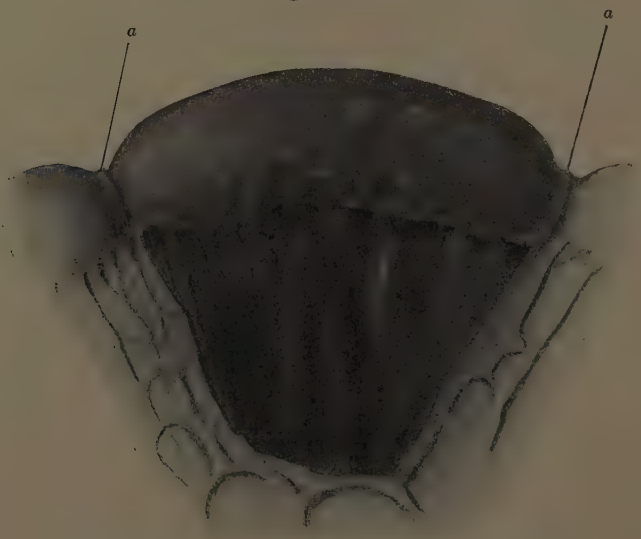

FIG. 350.—TRAUMA OF THE MESENTERY (Erdmann).
a, *a*, Cord-like contractions.

occluded, gangrene of the portion of bowel which it had supplied is sure to occur. Slits in the mesentery may lead to subsequent hernia. Hence in laparotomy for abdominal wounds careful search for mesenteric injuries

must be made. Wounds must be closed by suture except where vascular injuries necessitate intestinal resection.

The cases of Erdmann[5] prove conclusively that subcutaneous lesions of the mesentery may occur without hematoma forming. The diagnosis of traumas of the mesentery are therefore most difficult to make without laparotomy, and we agree with Erdmann, who makes it a rule in all cases of abdominal contusion to explore the abdominal contents by laparotomy if the patient has any abdominal rigidity or pain, whether or not there is evidence of blood in the vomitus, feces, or urine. If the patient is in shock at the time of observation, preparation should be made to open the abdomen, since hemorrhage may be the cause of the shock. The illustrations (Figs. 349 and 350) present the appearance of lesions found by Erdmann in subcutaneous injuries of the mesentery.

Disorders of the Circulation in the Mesenteric Vessels.—Sprengel[6] considers that the consequences of injury to the mesenteric vessels may express themselves either as bloody infarcts of the bowel wall or as anemic gangrene. The first is the result of closing a certain arterial or venous territory; the latter occurs only when, upon the blocking of a certain arterial region, the retrograde blood-stream is closed. Anemic gangrene must, therefore, on account of this very limitation of its mode of origin, be the rarer form.

The clinical manifestations of these circulatory disturbances are divided into two categories: intestinal hemorrhage with its consequences of bloody diarrhea or vomiting; second, the phenomena of well-marked intestinal obstruction.

In *hemorrhagic infarct* Sprengel maintains that, as the result of the hemorrhage into the bowels, bloody discharges may occur, while hemorrhage into the peritoneal space gives rise to early sero-hemorrhagic effusion into the peritoneum. Hemorrhage into the intestinal wall gives rise to thickening of the bowel wall, even to the degree of palpability through the parietes. As the result of hemorrhagic infiltration of the intestinal muscularis, gradual stiffening may slowly cause occlusion. Late peritonitis may occur as the result of gradually completed necrosis.

In *anemic gangrene*, as the result of the paralysis of all the intestinal layers by local death, early occlusion may take place with distention of the abdomen due to congestion above the diseased part of the bowel. Necrosis of all the intestinal layers may cause early peritonitis due to perforation.

The **diagnosis** is universally considered very difficult. In two of his cases Sprengel made a correct diagnosis. Confusion of cases of hemorrhagic infarct with invagination is easy. Severe initial pain occurs in both diseases; vomiting is also present in each disease. Discharges from the bowel of bloody fluid take place without escape of gas. The patient experiences no relief from the movements of the bowels. In both diseases the gradual loss of strength and the occurrence of a palpable resistance in the abdomen are quite similar.

The history is to be considered, especially with reference to those diseases which give rise to embolism or to other forms of mesenteric

vascular occlusion. Sprengel calls attention also to the study of abdominal resistance. At first a tympanitic note was obtained, while later the zone in question gave distinct dullness. This he attributes to the gradually increasing thickening of the intestinal wall. The age of the patient is to be considered, invagination occurring usually in younger patients.

In anemic gangrene the diagnosis is even more uncertain. The strangulation of the loop of bowel by incarceration in a peritoneal pocket can give rise to symptoms like those of anemic gangrene. A sudden beginning with severe initial pain, the relations of the bowel movements and passage of gas, the continued vomiting, abdominal distention, especially in the mesogastrium, with freedom from involvement of the lumbar regions, distinct intestinal rumblings and slight dullness upon the left side, with freedom of the hernial openings,—all these things are suggestive of occlusion of a bowel in a peritoneal pocket. Of course, a heart lesion and the anamnesis of an old peritoneal inflammation have their diagnostic place.

The **results of operative treatment** thus far have been very bad. Elliot in the year 1895 published the first successful case.

Sprengel publishes a case of which the following is a brief abstract: The patient was a tailor thirty-eight years of age. Twenty years before he had had peritonitis, lasting about five weeks. He was otherwise well, was married, and had five children. One evening after supper, while engaged at his work, he was seized with a sudden pain in the abdomen, followed by vomiting. Pains and the vomiting lasted for four days, when for a time the symptoms disappeared, to begin again after a few hours. The bowels had not moved since the beginning of the disease. On admission the patient did not seem very sick, nor did he feel ill. The pulse was regular, of good quality, 80 to 84 per minute. The respiration was not hurried, diaphragmatic breathing was distinctly present, the heart was normal. The abdomen was distended more in the umbilical region than upon the sides. The epigastrium was distended. Distinct dullness in the left lumbar region extended not quite to the external rectus border. Splenic dullness was not increased, the right iliac region was free, and intestinal râles were everywhere distinctly heard, increasing after long palpation to loud audible gurgling. The hernial openings were free, rectal examination was negative and periodic, well-marked singultus was noted. The diagnosis of obturation ileus was made involving the lower part of the ileum. While it was thought that there was no free peritonitis, a moderate exudate was diagnosticated upon the left side.

Laparotomy was done in the median line. Moderate quantities of red brown, cloudy fluid escaped, the small intestine issuing from the abdomen strongly distended and reddened, with surfaces slightly dulled. The intestinal loops were allowed to escape from the abdomen, and in the lower iliac region an exquisitely gangrenous part of grayish-brown color, which disappeared upon contact, made its appearance. Although the loop fixed in the region of the promontory was immediately lifted up and the neighboring loops of bowel that were apparently healthy were

secured by clamps, large quantities of the contents of the small intestine were discharged into the free abdominal cavity. More exact examination showed that the gangrenous part was about 10 cm. long and about 30 to 40 cm. above the ileocecal valve. It was sharply separated from the oral as well as the aboral part of the bowel. A tolerably well recognizable line of demarcation about parallel to the bowel could be seen in the mesentery. Upon cutting away the mesentery no ligation was necessary. The intensely filled small intestine was emptied; after careful cleansing of the bowel and peritoneum the two ends of the intestine were fastened into the abdominal wound; a large tampon was placed at that part of the abdomen where the gangrenous intestine had lain, and the abdominal cavity was left open. The course of the disease after operation was favorable. Singultus occurred for several days, though the pulse remained about 90. Gradually the discharges ceased, except drainage from the intestine, and the wound took on a normal appearance. Some time later the artificial anus was treated by operation, the two ends of the bowel being united by sutures after their separation from the abdominal wall.

Contraction of the Mesentery.—The mesentery not infrequently undergoes a process of contraction or shrinking which has received most consideration where the process has involved the mesocolon (*q. v.*).

O. Brehm,[7] after a careful study of mesenteric contraction, makes the following important statements: "Mesenteric shrinking is not only to be regarded as the etiologic moment in volvulus of the sigmoid, but also as a disease, *sui generis*, which urgently demands treatment. It is not only a disease of older persons, but may even occur in young individuals in exquisite form. Attacks of transitory occlusion from mesenteric contraction must be separated from true volvulus. They are to be treated as far as possible expectantly, and the patients are to be operated upon by entero-anastomosis or resection in the intervals of freedom from attack. If the mesenteric contraction has brought about the volvulus or occlusion by total angulation, laparotomy with exposure of the flexure is indicated. Simple detorsion of the loop does not suffice in mesenteric contraction; for protection against recurrences a radical operation must be added, such as resection or entero-anastomosis (cecum with rectal limb of the flexure) or ileocolostomy. Restriction of the operation to the making of a fecal fistula without exact orientation of the abdominal cavity is an error. Diagnosis of ileus is definitively to be given up, and in every case of intestinal occlusion a more accurate anatomic diagnosis is to be sought, in spite of frequent unavoidable errors. The indications for the operation are self-evident.

Mesenteric cysts belong to the rarities of surgical observation, though they seem to be four times as common as the solid tumors.

Serous, chylous, hemorrhagic, dermoid, and echinococcus cysts have been observed.

The chylous cysts are due to the dilatation of the chyle ducts. But of the origin of serous and hemorrhagic cysts little is known.

In view of the benign character of the malady no symptoms are to be expected except such as result from pressure. The bowel may be compressed or a volvulus may take place by the action of the cyst mass.

The **diagnosis** of the nature of such tumefactions is usually very difficult until the abdomen is opened.

The **treatment** of mesenteric cysts has been specially studied by Frentzel,[8] who urges that operations for these tumors should be undertaken as soon as their existence is recognized. The exact diagnosis is to be made by laparotomy only, puncture being out of the question. The typical treatment consists in total enucleation in case the intestine is not involved, but in case blood-vessels leading to the bowel are compromised, a resection has to be practised. Drainage may be necessary in rare cases, but is by no means to be preferred.

Mesenteric cyst, according to MacLaren,[9] is one of the rare causes of *acute intestinal obstruction.*

A man sixty-five years of age, says MacLaren, had a short attack of abdominal pain, his previous history being negative. There were symptoms of acute intestinal obstruction, but on examination the cause was indefinite. Laparotomy was performed, and the cecum was found to be collapsed. On following the small intestine upward for about eight or ten feet it was found dipping abruptly into the pelvis. Here a fluctuating tumor was felt. Upon elevating the small intestine, the tumor was induced to rise with it out of the pelvis, and was brought out of the incision, giving a sensation very similar to that experienced when lifting out a small ovarian cyst. The cyst had for its base the upper surface of the mesentery and a quarter of the circumference of the adjoining small intestine. It was removed by enucleation without difficulty and without hemorrhage; the peritoneum was brought together over the bared area with catgut and the abdominal incision closed. The recovery was uneventful.

The cyst was smaller in size than the fist. By falling into the pelvis it produced obstruction in two ways: From its attachment to the upper and anterior surface of the mesentery, when it descended into the pelvis it produced a horizontal *rotation* of the loop of small intestine from before backward. There was clearly a partial volvulus. Secondly, the cyst from its displacement into the pelvis *dragged* strongly upon the loop of intestine. The obstruction was caused, therefore, by both volvulus and traction. The cyst was yellowish in color, smooth, lobular, and fluctuating. The contents were fluid and yellow, and microscopically showed débris, but no fat cells. The cyst wall was made up of a somewhat cellular and highly vascular connective tissue. This cyst was of the serous variety.

According to Nothnagel, the majority of mesenteric cysts are situated well to the right of and a little below the umbilicus. This point corresponds to the most common situation for cysts in the mesentery of the small intestine.

E. Fuchsig[10] describes a case of a child in which there existed an atresia and hypoplasia of the ileum of a congenital character, resulting from the

fetal displacement of the bowel into an opening in the mesentery. In this case death having resulted from intestinal occlusion, a post-mortem examination was made upon the body of the child, which had lived but three or four days. The thoracic organs were normal. The stomach, duodenum, and jejunum were normally formed, as was the case with the uppermost loops of the ileum. About 60 cm. above the ileocecal valve the ileum was enormously dilated and hypertrophied, showing here and there a diameter of almost 4 cm. This distended part was 40 cm. long. At the central end of the distended bowel, that is, 55 cm.

FIG. 351.—CONGENITAL ATRESIA AND HYPOPLASIA OF THE ILEUM DUE TO FETAL DISPLACEMENT OF THE BOWEL INTO AN OPENING IN THE MESENTERY (Fuchsig).

above the ileocecal valve, the intestinal wall was very much thinned and showed a perforation of pin's-head size. At about 20 cm. above the cecum the distended part passed over sharply into a very narrow part of the bowel which ended 3 cm. above the cecum and was 18 cm. long. The colon and rectum were normally formed. The hypoplastic part of the ileum fitted exactly into a gap in the mesentery. The author believes that during fetal life the hypoplastic part of the bowel had occupied this space in the mesentery and had therefore failed to develop.

HEMORRHAGE AFTER GASTRIC AND INTESTINAL OPERATIONS.

It is well known that after various operations upon the body hemorrhages can take place, either in the stomach or bowels. After a study of the reported cases of this accident, Busse[11] states that gastric and intestinal hemorrhages occur with about equal frequency in men and women after operations upon any part of the body, but especially after

operations about the abdomen. These hemorrhages occur from the direct or retrograde movement of thrombi in the arterial or venous stream. It is requisite that in the occurrence of these hemorrhages a further and additional moment of trauma shall occur. Usually such hemorrhages are multiple, and occur for the most part during the first week. The anatomic alterations found consist of hemorrhages, erosions, and ulcerations in the stomach and intestines. Anatomic alterations are frequently absent. Though the lesions are of such serious character and consequence, rendering the prognosis grave, it is best to follow a symptomatic course of therapy, abstaining from operative intervention.

RUPTURE OF THE INTESTINES.

Rupture of the intestine may occur by the application of force from within the bowel as well as from without. Nicholas Senn, in May, 1888, read before the American Medical Association a most valuable paper upon the distention of the gastro-intestinal tube with water and with air. He showed that the pressure which was necessary in order to rupture a healthy intestine in the cadaver was greatly in excess of that which was required to force air through the ileocecal valve, or even the whole length of the alimentary tube. He showed that it requires but ¼ of a pound to 1½ pounds of pressure to drive air through the ileocecal valve, and from ½ pound to 2½ pounds to force it from the anus to the mouth, while even the weakest portion of the gastro-intestinal canal effectually resisted a distending force of from 8 to 10 pounds. He states that the ileocecal valve in a normal condition yields to an air pressure of 1½ to 2¼ pounds.

In the use of *fluids*, however, to distend the large intestine, there is great danger of rupturing the colon, because Senn has shown by his experiments that the ileocecal valve is not permeable to fluids from below, and that for diagnostic and therapeutic purposes it is unsafe and unjustifiable to attempt to force fluids beyond the ileocecal valve.

It is of great importance that physicians shall understand that the use of enemas under high pressure is extremely dangerous. The following case came under the writer's observation:

A man aged about fifty-five suffered from a mild attack of appendicitis, his physician considering that no operation was necessary, the symptoms being so slight. It was, however, thought desirable to have the bowels move by the use of enemas, and for that purpose injections of moderate quantities of water were unsuccessfully tried. A professional male nurse who was supposed to have special skill in the use of so-called high enemas was then called in, and by him injections were given in the knee-chest position. Large quantities of water were used to distend the bowels, to such a degree that the patient experienced extreme agony. At last the patient was unable to endure the torture any further, and the operator desisted from further manipulation, allowing the water to be discharged. The patient, however, went into a collapse, from which it was difficult to revive him. Consultants were hurriedly brought in,

and a diagnosis of rupture of the appendix having been made, the abdomen was opened. To the surprise of the operator and his assistants no serious disease of the appendix was found which could account for the grave collapse. Upon exploring the colon several longitudinal lacerations of the external coat were found, and at one point a small artery had been lacerated and was still spurting, allowing the discharge into the abdomen of a large quantity of blood. The blood was removed, the hemorrhage checked, and the patient made a slow recovery.

This case illustrates well in a clinical way the fact brought out by Senn in the paper referred to, that overdistention of the colon does not result in forcing the fluid through the ileocecal valve, but produces one or more longitudinal lacerations of the bowel.

Leftwich ("On Siphonage and Hydraulic Pressure in the Large Intestine") has endeavored to show that the large intestine acts as a siphon, that fluids introduced at the cecum are carried over to the rectal ampulla by a siphon action, and that, conversely, fluids introduced at the anus are quickly carried by reverse action to the cecum.

Without discussing the validity of the theory that the colon acts upon the physical principle of a siphon, we may agree with Leftwich that the movements of fluids and gases are usually very rapid and effective.

I observed with B. W. Sippy for a long period a woman who was the unfortunate victim of fecal fistula at the cecum which had resulted from a neglected appendicitis, a considerable portion of the wall of the bowel having sloughed away and a large opening existing through the skin and the bowel. Sippy conducted a series of observations by injecting fluids into the bowel from below and observing the length of time required for the transmission of the fluid to the fistula. It was found that fluids introduced within the anus were carried in a few moments to the cecum, proving the futility of giving so-called "high enemas."

E. Wyllys Andrews[12] publishes five cases of subcutaneous rupture of the intestine treated by laparotomy. Andrews advances the idea that the bowel is cut in two by the angle or promontory of the sacrum, against which it is forced when the anterior abdominal wall is pushed against the spine.

Operation should be done at once, by making a large median incision below the umbilicus, washing the peritoneum, and temporarily lifting such parts of the bowel from the abdominal cavity for treatment as may be required.

GUNSHOT WOUNDS OF THE INTESTINE.

Gunshot wounds of the intestine, the mesentery, and the omentum theoretically demand the closure of perforations of the bowel and ligation of bleeding vessels at the earliest possible moment. The fact, however, that abdominal penetrating wounds produced by the modern small firearms recover in a large percentage of cases without intervention has led to much discussion of the practical requirements of such injuries.

Simple perforations of the bowel not involving the blood-supply or

causing extensive laceration may be treated, once the abdomen is opened, by the application of Lembert sutures in such a manner that the lumen of the bowel will not be compromised; but it is to be remembered that, even where the caliber of the bowel is diminished considerably by suture, the tube will accommodate itself to new conditions with extraordinary facility provided the wound itself does not extend about the circumference of the organ, so that a considerable portion of the periphery of the tube is in a normal and therefore dilatable condition.

Where extensive injuries have occurred, the intestines will be managed according to the general principles; resections with anastomosis being in order where the lesion is extensive.

A large number of deaths occur in actual practice from injuries to the mesenteric and omental blood-vessels. Most of the cases of profound shock following penetrating abdominal injuries are due to extensive hemorrhage. Immediate laparotomy is the only course which is likely to be of avail where large vessels are injured, though a hemorrhage from smaller arteries and from some veins may cease spontaneously if the patient is kept quiet and sedatives are used.

The exigencies of surgery upon the battle-field will be discussed in the chapter on military surgery in this volume.

INTESTINAL OBSTRUCTION.

Intestinal obstruction is to be considered as either dynamic or mechanical, while the latter is to be divided into two classes—the obturation and strangulation forms.

Dynamic obstruction depends simply upon a failure of the contractility of the intestinal wall to overcome the resistance offered. Mechanical obstruction postulates the presence of an actual mechanical force intervening to prevent the flow of the fecal current. The great majority of cases of dynamic ileus owe the failure of power to the paralysis of the bowel wall, as in peritonitis. But local spastic contractions may be a cause of obstruction.

Cases of dynamic obstruction are by no means common except in peritonitis, yet they are clearly enough marked to be distinctly recognizable as forming a nosologic entity. It must not be forgotten, however, that in practice a great many cases which one would be tempted to call instances of dynamic obstruction are in reality due either to the usual causes of obstinate constipation or to the presence of slight adhesions which for one or another reason give way after a time.

A good illustration of dynamic obstruction is a case cited by Kocher. A child two years and three months old, supposed by the attending physician to be suffering from an abdominal tumor, was referred to the hospital. In the summer of 1891 there was an enormous distention of the abdomen, followed by frequent watery discharges of normal color. In January, 1892, the distention became greater, the stools remaining as before. Vomiting occurred occasionally; the patient complained of thirst and had dry lips. When the patient was admitted to the hospital,

in April, 1892, he showed moderately good nutrition, the color of the skin was excellent, but the abdomen was enormously distended, showing numerous dilated veins. The distention of the abdomen was irregular, the right hypogastrium was strongly distended in a hemispheric shape, while the left side was distended more toward the median and upper parts of the abdomen, and showed a surface thrown into large folds or waves. Over the tumor and the right hypogastrium, which was exquisitely elastic, absolute dullness was felt. Rectal palpation disclosed at the level of two centimeters two fecal masses of very firm consistence, which hindered the introduction of the finger. Upon catheterization 200 c.c. of clear urine were withdrawn. The temperature on admission was 37.4° C.; pulse 160. For more than a month the patient was cared for by the administration of small quantities of food by mouth, while frequent washings of the bowels with warm water, together with the introduction of the finger to remove hard fecal masses, was practised. At the end of May the patient was discharged much improved, although still pale. The abdomen was no longer dilated and the bowels moved freely. This was a case of pronounced coprostasis. The cause may perhaps have been partly referable to congenital dilatation of the colon, but the presence of adynamia of the intestine is incontrovertible.

By *obturation* of the bowel is meant the simple closure of the bowel for the passage of the fecal current with minimum injury to the intestinal wall itself. Experiments consisting in the simple transection of the bowel with closure of the ends by suture, in experimental animals, have long since shown that the subject was scarcely affected by the operation except that the fecal matter, being unable to pass onward, gradually to a greater or less extent filled the tube, and, regurgitating into the stomach, was vomited again. A dog operated upon in this way ejects the accumulating fluids by vomiting and eats again with appetite. Death eventually occurs from starvation (inanition). This result is reached the sooner, the higher the point of obstruction in the intestinal tract.

Strangulation of the bowel includes not only obturation but also compression of the wall of the intestine, giving rise to interference with the blood-supply and nerve-supply of the bowel.

Morbid Anatomy.—The injury which is done to the bowel wall in strangulation by simple distention of the intestine without any lesion of the mesenteric vessels has been shown by Kocher to be very great. He demonstrated by experiments on dogs, ligating a coil of intestine at two points and injecting fluid or air at the point of ligation, that a pronounced venous stasis can be brought about while the mesentery is in no way injured. He showed also that a patient with strangulated hernia may die from the effects of the alteration which the bowel has suffered within the abdominal cavity above the point of strangulation. In cases of strangulation he therefore recommends resecting the bowel high above the point of constriction. The overdistention produces extensive pathologic consequences in the bowel wall. Arnd showed that in strangulated hernia the circulatory disturbances permit microorganisms to pass into and even through the intestinal wall. General

intoxication naturally occurs as a result of the resorption of ferments, etc. Just as is the case in strangulated hernia, so in intestinal obstruction, quantities of fluid are poured into the intestine from the mucous membrane, partly from hypersecretion, partly from inflammatory exudation, and partly from hemorrhage. The fermentation of all of this material together with the venous stasis may result in the destruction of the intestinal epithelium. Circumscribed necroses take place, the mucous membrane and underlying tissues are cast off, especially where venous stasis has led to ecchymoses, and the ulcers may even perforate, to the production of peritonitis. Kocher thinks that the importance of these lesions has not been sufficiently recognized. Certainly surgeons should

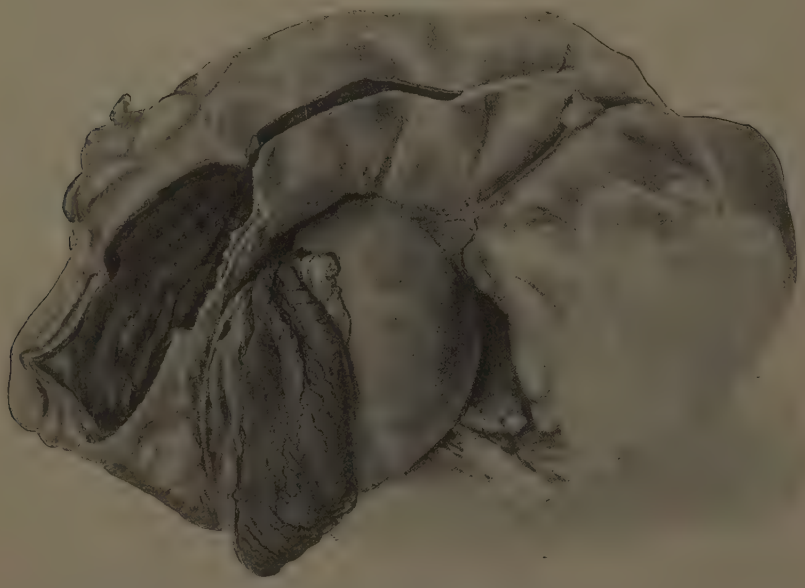

FIG. 352.—TWENTY-FOUR INCHES OF SMALL INTESTINE RESECTED FOR CHRONIC COPROSTASIS AND OBSTRUCTION DUE TO POST-OPERATIVE VENTRAL HERNIA AND ADHESIONS.
A large coprolith is seen through the incision in the intestinal wall. A piece of skin was removed before the hernia was closed.

be familiar with the fact that the bowel above the point of obstruction is not in a normal condition, and in operative treatment should be governed accordingly. Kocher considers that the most important point in the treatment of obstruction is the drainage of the bowel above the lesion.

Intestinal occlusion may be caused by malformation of the bowel (atresia, Meckel's diverticula) or of its mesentery, by peculiarities of the abdominal wall, the peritoneum, the omentum, or the diaphragm, or by undescended testis; by diseases of the intestinal wall, as scars or tumors; by inflammatory processes; by the results of traumatism, operative or otherwise; by abnormal intestinal contents; or by dislocated organs or by tumors (Prutz).

Symptoms.—The symptoms develop in a few hours or days in acute obstruction, while when the time required for their evolution is much greater the disease is said to be chronic.

In simple obturation the symptoms are almost wholly those due to interference with the fecal current. Such cases are usually due to the gradual diminution of the caliber of the bowel until the fecal current can no longer pass. Gases and fluids accumulate, violent peristalsis ensues with colicky pains, and energetic stiffening of the bowel occurs above the obstruction, due to spasmodic contraction of its coats. The appetite fails, nausea occurs, and vomiting begins with the discharge of the contents of the stomach, then of the duodenum, and at last of the parts just above the point of obstruction, the odor and other characteristics of the ejecta depending on their origin and on the fermentative processes to which they have been subjected. The vomiting in simple occlusion is due almost wholly to a sort of overflow of the gastro-intestinal tract. The fermentation of the retained intestinal contents leads, naturally, to the production of gases which may enormously distend the abdomen.

When to the condition of simple occlusion are added the results of strangulation of an intestinal coil the symptoms are usually very different. The pain comes on suddenly, is violent and spasmodic or colicky, and is intimately associated with great depression and vomiting. Efforts to move the bowels are unsuccessful except as to the part below the point of obstruction. The discharges obtained may consist at first of some feces and gas; while, if such lesions as those of intussusception are present blood-stained mucus may be observed and a sort of diarrhea may occur. The peristaltic movements of the intestine are not, as a rule, visible, as they are in "partial obstruction" (stenosis), where the long-standing hindrance has caused hypertrophy of the musculature.

Shock or collapse may be the expression of the reaction on the part of the nervous system, and this depression may be profound. The heart often responds by a pronounced slowing of the pulsations. Perspiration may be secreted profusely and the urine diminish greatly in volume, especially if the obstruction is situated high up.

It seems probable that the typhoid-like symptoms are due to resorption of intestinal poisons.

Prognosis.—While it is true that cases of intestinal obstruction are reported as recovering spontaneously, the diagnosis in such cases is always subject to criticism, the nature of the obstructing mechanism being in the main unknown. But it is not to be denied that in unusual instances spontaneous relief of most serious anatomic difficulties may occur.

According to the compilation of Kocher from the statistics of Golddammer and Buelau, about one-third of the patients suffering with intestinal obstruction, as clinically diagnosticated, may be saved by medical treatment or the treatment by delay. Of 288 cases of ileus studied by Naunyn, recoveries by laparotomy on the first and second day amounted to 75 per cent.; but on the third day only 35 to 40 per cent. could be cured by operation. The necessity, therefore, for early surgical intervention was clearly shown.

Diagnosis.—The diagnosis of intestinal obstruction in the plainly marked and typical cases is easy, but there are many instances in which a correct solution of the problem is impossible.

In stenosis or incomplete (partial) occlusion this is especially the case. Here Nothnagel[13] lays especial stress on the value of intestinal stiffening (*Darm-steiffung*) and exaggerated peristalsis as indicating increase of muscular activity and power in the effort to overcome resistance. The waves of peristaltic movement may often be seen and felt, while auscultation reveals gurglings and râles suggestive of the movements going on within. Alternating attacks of diarrhea and constipation occur, especially when the large intestine is the seat of stenosis.

In complete occlusion the canalization symptoms—*i. e.*, those signs referable to the interference with the function of the intestine as a tube—are of prime importance. Such are complete cessation of bowel movements, including gas, meteorism, and vomiting.

Some of these symptoms may be present in hysterical or nervous patients, in whom the observations must be exactly and carefully controlled in order to avoid error.

Certain toxemias and poisonings, as lead-intoxication, may give rise to serious error. Acute obstruction may best be excluded by observing the discharge of even minute quantities of gas with the enemas.

Feculent vomiting often occurs in the course of peritonitis involving the bowel. Here we usually have dynamic obstruction due to inflammation of the bowel wall, with paresis or even local paralysis. The practitioner in such cases seeks carefully for the signs of peritoneal inflammation.

In the search for the site of the obstruction the analysis of symptoms by Tavel is illuminating.

Symptoms of Occlusion of the Different Points of the Intestinal Canal.—We leave aside here the general symptoms that depend less upon the seat than upon the nature of the occlusion, its duration or degree of strangulation, etc.

Pyloric Occlusion.—Vomiting mucus, mixed sometimes with blood and food particles. Stools rare, emission of gas infrequent. Pains in the epigastric region and in the back. More or less pronounced distention of the stomach. Resistance in the pyloric region.

Duodeno-ampullar Occlusion.—The same symptoms as those of pyloric occlusion plus icterus.

Duodenal Occlusion.—Vomiting of food with or without bile and pancreatic juice. In the stomach bile and pancreatic juice in abundance. The vomitus is very abundant, the patient rejecting much more than he takes. The stools and gas are rare or completely lacking. Regional meteorism of the epigastric region. Retraction of the region below the umbilicus, at least in comparison with the enormous distention of the stomach.

Jejuno-iliac Occlusion.—Vomiting at first of mucus mixed with bile, later fecal vomiting. Stools and gas almost entirely absent. Regional meteorism of the middle part of the abdomen more or less pronounced in proportion to the high or low seat of the occlusion.

Ileocecal Occlusion.—Vomiting rarer and less frequent than in the preceding form. Stools and gas wholly lacking. Regional meteorism without involvement of the colon. Localized tenderness in the ileocecal region. Tenderness in the right half of the pelvis to rectal or vaginal touch in many cases. Occlusion of the hepatic flexure. Vomiting is late; may be lacking altogether. Stools and gas absent. Pronounced meteorism with more or less involvement of the diaphragm. Distention of the ascending colon. Pronounced tenderness in the hepatic region. Enemas well tolerated.

Occlusion of the Splenic Flexure.—Vomiting late or absent. Stools and gas absent. Meteorism pronounced with marked involvement of the diaphragm. Distention of the ascending and transverse colon. Tenderness in the region of the left hypochondrium. Large enemas are not so well borne.

Sigmoid, Iliac, or Pelvic Occlusion.—Vomiting late or absent. Stools and gas absent. Meteorism very pronounced. Colon distended. Embarrassment of the heart. Occasional disappearance of dullness of heart and liver. Small enemas are more or less well supported according to the seat of the obstruction. When the seat of the obstruction is in the ileum, palpation enables one to determine it; but if the seat of the occlusion is in the pelvis, the obstacle cannot be felt as a painful point to external palpation. Rectal or vaginal palpation enables one then, ordinarily, to detect it.

Rectal Occlusion.—Vomiting slow or absent. Stools and gas absent. Serious embarrassment of the viscera. Even small enemas are not well supported. Rectal touch determines the location of the obstacle.

LeGlay[14] attacks the use of the Trendelenburg position in laparotomy, alleging as one of the complications likely to be observed after its use intestinal occlusion by torsions of the bowels as the result of their displacement upward, and flexions resulting from old, band-like adhesions, especially to the transverse colon. As a prophylactic against the occurrence of intestinal occlusion, he recommends lowering the table before closing the abdomen and a careful arrangement of the intestines before introducing the sutures of the abdominal wall. If the abdominal cavity has not been opened, he recommends a slow return of the patient to the horizontal position and care to avoid violently shaking the patient. In the latter cases he makes particular reference to operation upon the bladder.

Congenital Stenosis.—Gärtner considers that stenosis of the small intestine may be congenitally due to axial rotation of the mesentery, persistence of the ductus omphalomesentericus, fetal peritonitis, inguinal hernia, compression of the bowel by a tumor, and strangulation of the bowel by the omphalomesenteric artery. Other causes may also be concerned, as Gärtner himself has admitted.

Stenosis.—Slight intestinal stenosis rarely gives rise to trouble, except that at the points of narrowing such diseases as tuberculosis and carcinoma can easily arise. All the disease processes in the intestine which run a typical course and may result in scar formation can produce

stenosis. Traumas, whether operative or otherwise, can give rise also to contractions. Ring-shaped strictures may take place, too, as the result of compression in strangulated hernia. The sewing over of suspected points of gangrene in incarcerated loops of bowel may give rise to narrowing of the bowel to a high degree, yet Crampe[15] shows that a permanent stenosis requiring operation belongs to the rarities. After invagination stenosis may also occur, yet even here an operation is rarely required for its relief.

The reason for this rarity of serious consequences following stenosis of the bowel lies in the fact that the force exercised by the contracting walls of the bowel upon its gaseous and fluid contents is very great, and compensation for partial obstruction takes place easily by hypertrophy of the intestinal wall. The degree of thickening of the intestinal wall may be very considerable.

FIG. 353.—INTESTINAL STENOSIS (Haasler).

If the cause of the stenosis is a disease which acts only for a time and is followed by recovery, the stenosis may be only transitory, the bowel above the point of injury gaining increased muscular power to compensate for the narrowing.

The case is quite different, of course, when the causal disease is of a progressive injurious character, like tuberculosis or carcinoma. The severe implication of the motor function conduces to exacerbation of the disease.

Simultaneous Stenosis of Intestine and Pylorus.—Payr[16] has discussed, very much to our benefit, the occurrence of stenosis at the pylorus at the same time that constriction takes place in the bowel. A series of difficult questions is raised under these unusual conditions. Payr has collected from the literature fifty cases, from which he deduces a number of important conclusions.

He states that simultaneous stenosis of the intestine occurs most frequently in round ulcer of the stomach with perigastritic changes. Appendicitis, when present with ulceration, may constrict the bowel by the formation of adhesions. Syphilitic fibrous scar contractions occasionally occur simultaneously in the stomach and bowels of the same patient. Malignant neoplasms may also produce simultaneous constrictions in different parts of the tube.

Perigastritis may lead to adhesions partly close to the stomach and

partly at a distance from it. An almost typical flexion of the colon may occur by the lifting up of the transverse part of the large bowel by adhesions to the ulcer-tumor. Syphilis and tuberculosis of the pylorus may produce simultaneous cicatricial stenosis of the bowels.

Payr considers it the best policy to endeavor if possible to relieve both points of obstruction at one operation. The following case, taken from Payr's paper, illustrates very well the method to be pursued in such complicated cases. A man fifty-six years old, who had been suffering for fifteen years from gastric symptoms, had a typical anamnesis of ulcus ventriculi. In each attack the hemorrhages of the stomach were very severe, the stools often presenting a tarry appearance for weeks; the intervals between attacks became shorter and shorter, so that recently hemorrhages and attacks of pain occurred about every two months. In October, 1902, a very severe attack occurred with intense peritonitic symptoms, so that the patient had to stay seven weeks in bed. Since that time a rapid emaciation occurred, the weight falling from 60 to 42 kilograms. The phenomena of pyloric stenosis in high degree became increasingly distinct. Shortly after each meal pain occurred in the pyloric region, with a tendency to vomit, with nausea. Frequently an hour and a half to two hours after eating food or acid fluid was vomited. Three to four hours after meals there was formed upon the right side of the abdomen a knotty tumefaction, and at the same time extremely severe colicky pains were felt radiating toward the left side. Frequently the patient became faint from pain. After a half hour these colicky attacks passed by. Frequently six to seven hours after eating, sometimes at night, there was vomiting of a brownish, very foul material. The movements of the bowels were constantly difficult.

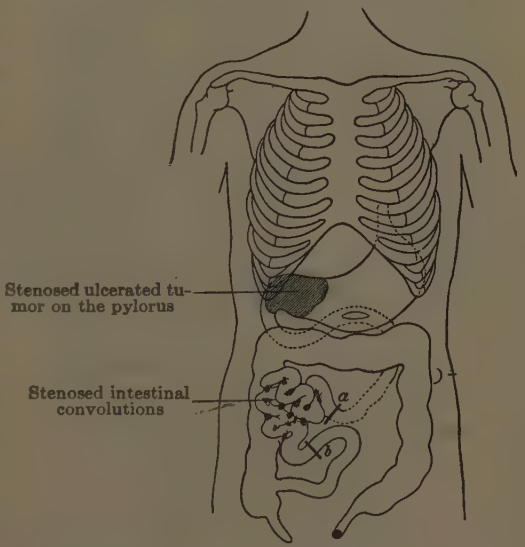

FIG. 354.—STENOSED ULCERATED TUMOR ON THE PYLORUS; COILS OF INTESTINE AGGLUTINATED BY NUMEROUS ADHESIONS (Payr).

Resection of 125 to 135 cm.; gastroenterostomy; intestinal anastomosis. *a* and *b*, points of resection.

Upon admission the man was found to be of medium stature and extremely emaciated. The distended abdomen presented a marked contrast in appearance with the pronounced emaciation of the patient. It was generally distended, especially in the region of the umbilicus and lower abdomen, less in the epigastric region. The liver extended below the right

costal arch about a fingerbreadth. Percussion gave a relatively dull zone below the right rectus muscle over an area about the size of a child's fist. Elsewhere the abdomen was tympanitic with no trace of dullness in the lumbar regions. Near the right costal arch and below it one could feel on repeated palpation a resistant mass with a smooth surface which was tender to pressure. To the right of the umbilicus one could note here and there a slight arching of the abdomen. The palpating hand felt increased resistance, which was immediately altered on pressure. On prolonged examination the resistance became plainer, and gave the impression of intestinal loops engaged in slight hyperperistalsis. Upon striking gently with the percussion hammer upon the abdomen these intestinal loops could be seen in heightened activity, slightly raising the abdominal walls. On one occasion during an attack of colic, the actively moving intestinal loops could clearly be seen and felt. At the same time loud whistling, gurgling, and squirting sounds could be heard, the loops engaged in this active movement occupying a space as large as a large fist.

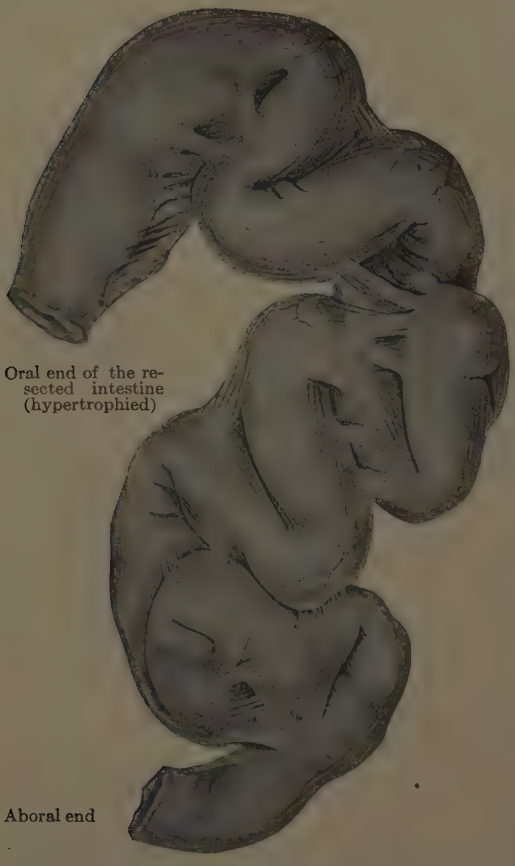

FIG. 355.—RESECTED INTESTINAL COILS. (SAME CASE AS FIG. 354) (Payr).

Distention of the stomach showed that the resistance felt behind the right rectus muscle belonged to the pylorus. Distention of the colon with air gave complete simultaneous filling up to the cecum and elicited no pain. Rectal examination was entirely negative. The vomitus contained an abundance of free hydrochloric acid.

The diagnosis was ulcer of the stomach, producing the recurring hemorrhages, with consecutive pyloric stenosis and motor insufficiency. It was difficult to explain the signs of a simultaneous intestinal stenosis. The most probable diagnosis was that of perigastric adhesions causing flexion at some point in the large intestine. But since Payr had regarded

the pronounced peristalsis of intestinal loops as belonging distinctly to the small intestine, the cause of the constriction was not considered as having been determined. Nevertheless, the operator thought of a simultaneous inflammatory process proceeding from the ulcer.

An operation was performed on the first of February, 1903, lasting one hour and twenty minutes. The stomach with its large curvature plainly in view was found hanging low. The pyloric part was fixed to the surface of the right lobe of the liver, and changed into a hard tumefaction the size of a small child's fist, of distinctly inflammatory character. There were numerous adhesions of the neighboring organs, especially with the liver, gall-bladder, and head of the pancreas. Fine thread-like adhesions existed between the tumefaction and the anterior abdominal wall, and the transverse colon appeared to be drawn toward the stomach, especially upon the right side. In vain, however, adhesions were searched for between the tumefaction, which evidently was produced by a callous ulcer of the stomach, and the neighboring intestinal parts. Hence the entire intestine was examined, and showed presently at a point corresponding to the junction of the ileum and jejunum a rather large portion of small intestinal loops matted together by numerous adhesions in characteristic form and frequently bent at acute angles, so that the supposition of obstruction of the small intestine was at once borne out. The limb of bowel leading to this convolution was dilated and its walls pronouncedly hypertrophic, the afferent loop being much smaller. By these adhesions of the loops of small intestines among one another marked U-shaped flexions were produced, and upon slightly striking them lively peristaltic movements could be called forth. No other lesion of the small intestine or large intestine could be found. No enlarged mesenteric glands or old ulcer scars on the surface of the bowels could be found. Careful measurement of the intestinal convolutions involved in the adhesions gave a length of from 125 to 135 centimeters. All the affected convolutions were resected, and the intestinal ends, in spite of the difference in their diameters, were united by a suture of double rows in an axial manner. For the relief of the pyloric stenosis and drainage of the stomach a posterior retrocolic gastro-enterostomy, after von Hacker, was

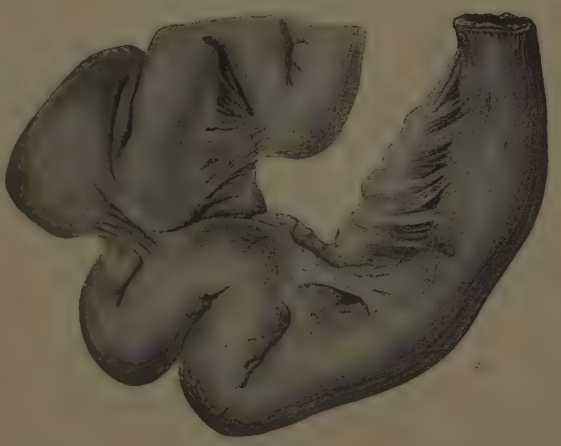

Fig. 356.—View of the Cicatricial Adhesions and Bands on the Convexity and Mesenterial Insertion of the Agglutinated Intestinal Coils (Payr).

carried out and the abdomen closed. Twenty days after the operation the patient left the hospital, having already increased in strength remarkably. Nine months after leaving the hospital the patient had gained almost 20 kilograms, was able to eat all kinds of food, and no longer thought of his former disease.

C. M. H. Howell[17] reports the case of a girl of four days, a full-time child, with no external deformity, who vomited shortly after birth and continued to vomit up to the date of admission to the hospital. When first seen the vomitus contained bile, and there was a history of this bilious vomiting for two days previous to admission. No meconium was vomited, but a small amount had been passed on the day of birth, after which nothing more was passed. The eighth day after birth the child died, having become progressively weaker since admission. The question of operation was raised and decided in the negative, though the result of autopsy showed that surgical interference might possibly have proved effective. The post-mortem examination showed that seven feet from the pylorus the small intestine came to an abrupt termination, and for a space of two inches was wanting, was then resumed as a patent tube and extended two feet further to the ileocecal valve. The upper part was considerably distended and the lower completely collapsed. There was no other abnormality, although the lower portion had undergone intussusception into itself for about two inches. It was noteworthy that meconium was passed soon after birth, and that it was of the ordinary color, though the bile can scarcely have reached the lower portion. In a case recently published by Emanuel[18] in the "Lancet," Aug. 12, 1905, in which there were multiple occlusions present, the same fact was noted, and the author quotes observations by Rolleston and Foster, stating that in congenital occlusion of the bile-duct on the one hand, and in congenital absence of the liver

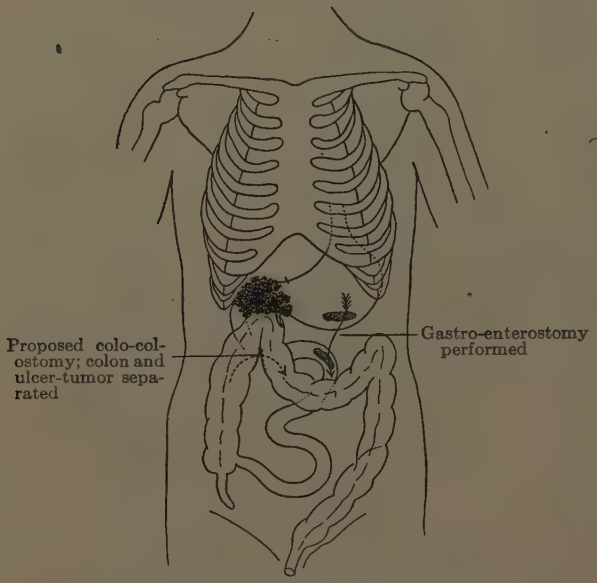

FIG. 357.—STENOSED ULCERATING TUMOR ON THE PYLORUS WITH ANGULAR BENDING OF THE TRANSVERSE COLON THROUGH ADHESIONS (Payr).

Plan of the colo-colostomy releasing the adhesions possible; defect in the walls of the colon; suture; posterior gastro-enterostomy.

on the other, apparently normal meconium was passed. Such abnormalities are fortunately rare.

Intestinal Stasis.—Intestinal stasis may be classified as partial and complete, or, again, as acute and chronic. The special types, such as intussusception, intestinal strangulation, etc., ordinarily classified under the heading of intestinal obstruction have already been discussed. Here will be considered only those cases falling on the dividing-line between medicine and surgery in which there is more than a condition of chronic constipation and yet not a clearly defined, unquestioned cause, such as a foreign body, stricture, or growth, to explain the condition; in other words, the ill-defined cases of intestinal stasis which baffle the internist and in which surgery may either cure the condition or be an adjuvant to medical treatment. It is not intended to discuss the subject of chronic constipation as a whole. This may be found in such treatises as those of Nothnagel, Hemmeter, and Illoway, and from whom I here abstract freely.

Illoway classified chronic constipation as follows:

(A) Chronic constipation produced by well-developed morbid processes: (1) Obstruction of the lumen of the bowel, strictures, growths of the bowel, tumors pressing on the bowel, adhesions, kinking. (2) By impairment of secretions poured into the intestines in chronic diseases of the liver and pancreas. (3) By inhibition of peristalsis through the nerve-centers. (4) Chronic venous engorgement of the portal system. (5) By voluntary abstention from stool on account of the pain it causes, by reason of a diseased condition of the rectum, stricture, fissure, hemorrhoids. (6) By changes in the mucous membrane which impair its irritability and render it incapable of performing its physiologic function in digestion, chronic catarrh, mucous colitis, etc. (7) By atony of the intestinal muscles, produced by morbid processes of the stomach and bowels, peritonitis, etc.

(B) Chronic constipation from foreign bodies.

(C) Chronic constipation from: (1) Malformations, abnormally developed colon; undue size or length of sigmoid flexure, diverticula of the large bowel, diaphragms in the large bowel. (2) Defective development or essential primary atrophy of the colon. (3) Enteroptosis.

(D) Chronic constipation from impaired physiologic function: (1) Perverted action—enterospasm, spasm of the sphincter. (2) Imperfect performance of physiologic function.

It can be seen readily that some of these factors become so severe as to demand intervention, and it is to these that we shall give our attention.

That patients can go two to three weeks without evacuation of the bowels and yet not suffer from any symptoms is well known, and conversely patients may have bowel movements regularly and yet a high degree of intestinal stasis develop, so that a history of frequent evacuation does not exclude the diagnosis of an intestinal tumor due to feces.

The relation of adhesions to constipation has been discussed at great length, and while they do not play the rôle that authors originally attributed to them, it is undoubtedly true that kinking of the bowel by the adhesions

can give rise to a high grade of constipation ending in partial or complete stasis. Strictures and growths, by a partial retention of feces, develop a vicious circle of impaired function and partial stasis that may end in complete stasis at any time. In slight or gradual stenosis hypertrophy of the muscular layer develops which may undergo fatty degeneration later, followed by a slowly developing paralysis the result of a long-existing coprostasis. The stasis developing from peritonitis, either general or local, has been the subject of much study. It is probable that here we have a continuation of inflammation into the muscular layer, or, if this has not taken place, the muscularis is at least penetrated by a serous transudate. Hemmeter reports two cases in which, as a result of trauma, there was an edema of all the coats so as to produce a temporary obstruction. The congenital hypertrophic dilatation has been discussed elsewhere, as has also the etiologic factor of enteroptosis. Concerning this, however, it must be emphasized that medical treatment should be tried before resorting to surgical intervention. A patient may have a high degree of enteroptosis without any symptoms, and, on the other hand, a vicious circle may be inaugurated that will ultimately demand attention. The mucous colitis and intestinal catarrh are often due to a pre-existing perisigmoiditis or peridiverticulitis or other chronic lesion, the colitis in turn producing a stasis, the whole demanding an appendicostomy or other operative procedure. The skeletal musculature may be the prime factor in inaugurating a series of disasters that will end in stasis. The relaxed abdominal wall leaves the intestines without that factor which aids in the evacuation of feces from the rectum. Pincus further maintains that those women who have suffered traumatism of the musculature of the pelvic floor experience increasing difficulty in evacuation, and ultimately a habitual constipation favoring final coprostasis.

Paralytic and dynamic ileus has been discussed elsewhere, but this type of coprostasis is so frequent as to merit further consideration here. It is due to a large variety of etiologic factors. It may affect a small part of the entire length of the intestinal tube. Formerly the symptom-complex known as paralytic ileus was believed to be due to paralysis of the bowel, but Henrot enlarged the conception conveyed by the term and introduced the terms pseudo-occlusion and pseudo-incarceration. Nothnagel says that while no one doubts that paralysis of the intestine may occur as a consequence of peritonitis or overdistention, yet the occurrence of a purely functional form, apart from nervous causes, is not generally conceded; some would regard the paralysis as toxic or bacterial; he, however, believes that a purely functional nervous paralysis does occur. Accepting this, paralysis of the intestine may be classified as follows: (1) Functional nervous paraylsis of the intestine. (2) Motor insufficiency due to marked anatomic lesions of the intestine, *e. g.*, embolism of the mesenteric artery, paralysis from overdistention by gas. (3) Toxic enteroparalysis, *e. g.*, drugs and toxins, acting on the nerves. (4) Paralysis of central origin, *e. g.*, tabes. (5) Reflex, *e. g.*, orchitis, renal colic. Whether this is followed by an enterospasm or enteroparalysis is not known.

Nothnagel maintains that the mechanism of intestinal obstruction here is as follows. The driving power of the intestinal wall becomes insufficient, and, as a result, the contents of the affected segments of the intestine remain stationary and are not propelled onward. Stasis of the bowel-contents and accumulation of fecal matter naturally occurs, the material successively filling the different portions of the intestine in a direction upward toward the stomach. These distended loops may kink the gut at fixed points. Leichtenstern explains certain obstructions as follows: The loops of intestine that are inflated and distended with gas, particularly if they have a long mesentery, always rise upward in the abdomen and occupy the highest possible position. When the patient is lying on his back, the inflated loops naturally rise upward and press against the anterior abdominal wall. On the other hand, the distended loops with a short mesentery, particularly the duodenum and first part of the jejunum, are fixed near the spinal column, and if the patient is lying in the dorsal position, the pylorus will be situated lower down than the distended loops of intestine, which have risen upward against the anterior abdominal wall. The natural result of this displacement is that liquid contents of the duodenum and of the upper part of the jejunum, in obedience to the law of gravity, run backward into the stomach. In this way gaseous distention produces results exactly the same as those of stenosis of the small intestine.

In the ordinary case the accumulation of feces from chronic stasis occurs in the large intestine. The masses may be of immense size. The etiologic interference with innervation is then reinforced by the pressure due to the increasing amount of feces, and ultimately complete occlusion of the bowel may result, either by a purely mechanical factor of accumulated feces or by the displacement of the heavy loops causing kinking in the bowel, or the functionating power of the intestine, which is already weak, becomes more affected by the accumulated mass, and complete loss of function ensues.

The **diagnosis** of these tumors is often difficult. The history may show regular evacuations, with a gradually developing tumor. It is more common in females than in males. They may be above the umbilicus, but generally if they are in the transverse colon, it is dragged down into the pelvis; and if it is in either the ascending or descending colon, it occupies a corresponding position. They may be of any shape or consistency, but frequently can be molded. Gersuny and others have drawn attention to the fact that when one draws the fingers away after deep palpation, he perceives a feeling of separation of the wall of the gut from the mass—a sort of sucking sensation. Chronic digestive disorders are frequently complained of, eructations, poor appetite and headache, and a slight temperature; pressure on lumbar and sacral nerves may give pain in thigh. The shape of the mass changes after repeated attempts to unload the bowel by enemas and local extraction of feces. Hemorrhoids frequently are present. Ulcers with local peritonitis may complicate the picture. The patient may develop an acute condition known as fecal colic,—violent colicky pains severe enough to produce syncope,—gas

accumulates, which may be expelled after an enema, vomiting may intervene, and in severe cases the patient may die with the symptoms and signs of acute intestinal obstruction.

The **treatment** of these cases naturally varies with the condition present and the causative factor. We will not discuss the medical treatment, since it is fully described in the medical text-books dealing with this condition.

In case an apparently complete obstruction is found with colic, the evacuation of the bowels must be brought about by large soapsuds colonic flushing, supplemented by enemas and removal of the feces with the aid of a spatula and kneading of the fecal mass. In manipulating the intestine for this condition, it should be remembered that the intestinal wall is thin and easily ruptured owing to the presence of fecal ulcers. Occasionally masses may be so hard that they cannot be propelled along the intestinal canal, and must be removed by laparotomy. This occurs especially in the cecum. These masses often develop in the ampulla of the rectum, and must be broken up by instruments and removed by the fingers or a spoon. After the mass is removed the patient should be observed carefully for some time, the bowels kept open, and the patient treated medically. The original cause of the trouble should be sought, and treated either by medical or surgical means as the condition may demand. Laparotomy and the breaking up of adhesions which cause angulation, the treatment of enteroptosis (see Enteroptosis), the restoration of the competence of the anterior abdominal wall, the treatment of colitis and chronic constipation by appendicostomy or cecostomy, the removal of the appendix, may any of them be demanded. Arbuthnot Lane[19a] has suggested more radical measures in these cases of chronic intestinal stasis—more radical, indeed, than is accepted at the present time. His theories and methods of treatment in brief are as follows:

"In the treatment of such degrees of overloading of the large bowel as cannot be treated efficiently by measures short of operation, I have obtained considerable success by dividing constricting bands and adhesions, and by subsequent careful attention to the proper functioning of the bowel. In a considerable proportion of cases, and more particularly in women, such means are insufficient, as at the best they only afford temporary relief, since the obstruction recurs sooner or later.

"In my earliest cases, after the appendix had been removed and the cecum and flexures freed from adhesions, on one or more occasions without any other than transitory benefit, I looked about for some means of relieving the patients of the cecal pain from which they suffered and for the relief of which they were ready to submit to any operation. In the first case I merely made a lateral anastomosis between the ileum and sigmoid, but the early return of cecal pain obliged me to divide the ileum. In several of these cases after an interval of months the patients were occasionally annoyed by the presence of hard, dry masses of fecal matter in the cecum. These produced no auto-intoxication, but the discomfort arising from the pressure was sufficient to make me remove the large bowel as far as the splenic flexure. They are not necessarily the result of re-

gurgitation, but are probably secreted by the large bowel. A still more extended experience showed me that if any portion of the large bowel is left above the junction with the ileum, it tends to dilate sooner or later. This dilatation may interfere with the satisfactory evacuation of feces, and discomfort or pain may ensue because of its distention by fecal matter or gas. Therefore to overcome the constipation as well as the septic absorption, the large bowel should be removed as far as its junction with the ileum, which is effected in the upper part of the rectum or in the adjacent sigmoid.

"Therefore, when I recognize that the mechanics of the intestines have been altered to a degree that cannot be rectified satisfactorily by the division of bands, etc., I divide the ileum at a distance of about five or six inches from the cecum. This can be done rapidly and securely by applying a strong compression forceps on the ileum, so as to reduce the bulk of the coats to the minimum possible.

"As the forceps is removed, the compressed band of bowel is ligatured by means of a sufficiently stout ligature. The ileum is divided by the cautery immediately beyond the ligature. The stump is then buried in the proximal bowel by means of a purse-string suture which encircles the bowel about three-quarters of an inch above its ligatured extremity, rendering the closure absolutely secure, and perforates its peritoneal and muscular coats.

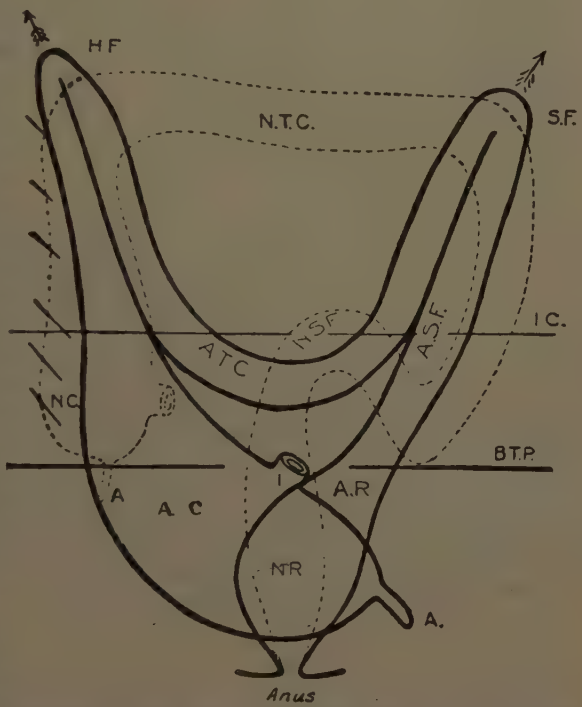

FIG. 358.—DIAGRAMMATIC REPRESENTATION OF MANY OF THE CHANGES WHICH THE LARGE BOWEL UNDERGOES IN CONSEQUENCE OF THE HABITUAL INTERFERENCE WITH ITS FUNCTIONS BY CONSTIPATION (W. Arbuthnot Lane).

The normal condition is shown as a dotted line, while the firm outline illustrates the modifications which take place in consequence of habitual overloading. N. C., N. T. C., N. S. F., and N. R. indicate what may roughly be regarded as the normal cecum, transverse colon, sigmoid flexure and rectum, while A. C., A. T. C., A. S. F., and A. R. represent these parts in their altered state. B. T. P. and I. C. show the lines of the brim of the true pelvis and of the iliac crests. The appendix is left free from adhesions or deformity, so as not to render the diagram too complicated.

"The acquired adhesions and peritoneum which bind the cecum and ascending colon to the abdominal wall external to them are divided and the bowel is raised till the vessels which supply it are exposed. These are grasped in compression forceps and firmly ligatured. The vessels supply-

ing the transverse colon are similarly treated, and finally the descending colon and sigmoid are removed, the rectum or the lower part of the sigmoid being occluded in the same manner as the ileum.

"I had usually been satisfied to divide the transverse colon at the splenic flexure, closing the distal portion in the manner already described, but for the reasons I have given I now remove the descending colon and the sigmoid, closing the large bowel at or just above its junction with the rectum.

"The termination of the ileum and the rectum adjacent to it are brought into convenient apposition, and a perfectly secure and reliable lateral anastomosis is made by means of a double row of continuous sutures, the inner row of which perforates all the coats, while the outer does not enter the lumen of the bowel.

"If the surgeon prefers it, the ileum and rectum may be united end to end. This is the better way, since any tendency to pouching which exists in the case of lateral anastomosis is avoided. The objection to it is that it is not so absolutely safe because of the difference in the circumference of the two pieces of bowel, the frequent great tenuity of the wall of the ileum, and the difficulty occasionally met with in dealing with the mesenteric attachment."

Obstruction by Meckel's Diverticulum.—An intussusception may be brought about by the presence of a Meckel's diverticulum in the same way as this would be produced by a polyp when, as in cases described by Treves and Bryant, the diverticulum has become invaginated with the intestinal tube. The peristaltic movements of the bowel may then force the invaginated diverticulum onward, the bowel wall being carried with it.

Strangulation by and of Meckel's Diverticulum.—Meckel's diverticulum may cause strangulation by the free diverticulum, when very long, producing a knot about a loop of bowel. Exceptionally, moreover, by torsion about itself or its loop of bowel the diverticulum may produce the same result. The inflamed diverticulum frequently becomes adherent to neighboring structures, producing stenosis. Axial rotation and flexion of the intestine may be produced about the adherent diverticulum (Kramer).

From 5 to 7 per cent. of occlusions occurring about the cecum are due to the implication of Meckel's diverticulum.

Intussusception or intestinal invagination is the slipping of one part of the bowel into the part continuous with it above or below. In the former case we speak of an *ascending* invagination, in the latter of a *descending* one. Naturally the descending form is by far the more common. The portion of bowel acting as the cover or casing is called the *intussuscipiens*, while the included part is the *intussusceptum*. The neck is that part of the bowel where the intussusceptum passes over into the intussuscipiens. The apex is the part of the intussusceptum projecting upwards or downwards into the cavity of the bowel.

Double invaginations have been described where an intussusception has itself become a part of an additional invagination process, so that

instead of a mass consisting of three cylinders we have one composed of five.

The circulating disturbances due to traction and compression of the mesentery are of the gravest importance and are in direct relation to the rapidity of onset and the tightness of the constriction (Nothnagel).

Venous stasis with exudation, infection, inflammation, and gangrene at the neck of the intussusceptum (Senn) constitute the prominent points in the morbid anatomic sequence.

In less intense degrees of strangulation adhesions may form between the peritoneal coats, rendering the anatomic relations permanent, while, the conditions of swelling and constriction disappearing, the intestine may again become patent.

On the other hand, after such adhesions have been formed, sloughing of the entire intussusceptum may lead to spontaneous recovery.

FIG. 359.—INTUSSUSCEPTION—ILEOCECAL. CHILD. RESECTION.

The writer observed one case of this kind in consultation with Elbert Wing. Wing watched an old man of about seventy years of age through a protracted attack of typhoid fever, at the close of which symptoms of intestinal obstruction were observed. A tumefaction was to be felt in the region of the ileocecal valve and blood and mucus were passed with the stools. The obstruction of the bowels was only partial. After a few days the wife of the patient, while assisting him with a movement of the bowels, was horrified to find a piece of tissue projecting. By pulling upon this mass, a piece of tissue that was afterward found to be a part of the ileum about 20 inches in length was removed. The patient recovered from the immediate effects of the intussusception, but later succumbed to intestinal obstruction, probably due to scar contraction about the site of the old lesion.

Hermes[20] has considered the subject of spontaneous elimination of the intussusceptum at some length, and has brought together the chief facts pertaining to it from the literature. He says that, while children

are afflicted in such an extraordinary degree with this malady, spontaneous discharge of the intussusceptum occurs in them with great rarity; but the relations with adults are quite the reverse. Two per cent. of all cases of spontaneous elimination of the intussusceptum occur in the first year of life, while 6 per cent. take place between the second and fifth years. Wichmann collected 724 cases of intestinal invagination. In forty-nine cases spontaneous discharge occurred before the fourth week, two after the fourth week, one after the second month, one after the third month, one after the fourth month, while in fifteen cases the time is not stated.

The mortality Wichmann states to be 3 per cent. after elimination of the intussusceptum.

Etiology.—Three important anatomic circumstances must be considered in relation to the etiology of intussusception: (*a*) the differences in diameter of the small and large intestines, (*b*) prolapse of the mucosa of the ileum, and (*c*) the abnormal length and mobility of the mesentery. D'Arcy Power emphasizes the relation of the diameter of the ileum to that of the colon. While the diameter of the colon is at birth only a few millimeters greater than that of the small intestine, and before birth their diameters are almost equal, at the fifth year the colon is from two to three and one-half times as wide as the ileum, since after birth the colon begins to grow, while the ileum enlarges but slightly. During the first month of life the disproportion rapidly increases, and Power thinks that the ileocecal valve may be less competent during this period, making intussusception easily possible. Power made accurate anatomic investigations on the ileocecal region. The axis of the ileum in relation to the cecum was horizontal in twenty cases, straight and obliquely downward in fourteen cases, concave downward in three cases, and convex downward in one case.

These statistics suffice to show that no exact relationship between these parts of the bowels can be considered the rule, so that we are easily able to understand how morbid changes in position can be brought about. Rilliet called attention to the relaxation of the colon in the internal iliac fossa as a cause of intussusception. Power referred especially to the length of the mesentery, finding the relation of the length to the entire body in nursing children much greater than in older children, from which he concludes that the range of mobility must be correspondingly greater in children.

Lorenz,[21] discussing the etiology of invagination, maintains that, so far as concerns those invaginations which involve the region of the ileocecal valve, in the majority of cases the beginning of the process takes place not at the ostium ileocæcale, but that it occurs by the rolling in of the cecum itself, so that actually a preliminary process occurs to which Lorenz gives the name of invaginatio cæcocolica. His illustrations also suggest the rôle that may be played by what may be called collateral morbid anatomic changes; as, for example, by the presence of an enlarged lymphatic gland or a Meckel's diverticulum.

Tumors as a cause of intussusception have been noted not infrequently. In the main they are non-malignant, and usually are located at the apex

of the intussusceptum and are chiefly pedunculated. As a rule, they occur in adults. Weiss,[22] in his study of the literature, refers to sixteen instances. Two instances were papillomata of the rectum with subsequent intussusception of the colon. In both cases after removal of the papilloma, the intussusception could be reduced with the hand introduced into the bowel as far as the elbow. Wagner was able to palpate a pedunculated fibroma in the case of an intussusceptio iliaca at the apex of the intussusceptum. Paltauf demonstrated a case of polyposis of the stomach and intestines with consecutive intussusceptio ileocæcalis. Treves reported a case in which three polypi caused three separate invaginations. Treves' view of the mechanism is not that the polyp precedes and, as it were, draws upon the intussusceptum, but rather that it excites an intense peristalsis at the point of its attachment.

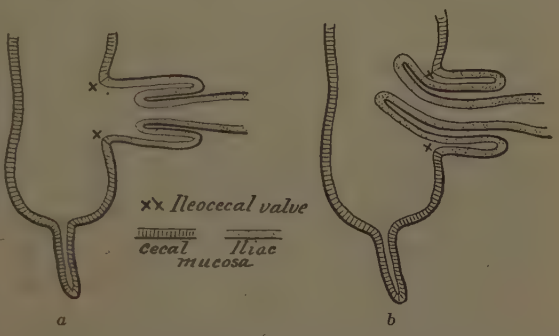

FIG. 360.—*a*, INVAGINATIO ILIACA; *b*, INVAGINATIO ILIO-ILEOCOLICA (H. Lorenz).

Benign tumors producing intussusception include also adenomata and fibromyxomata. Marchand described a subserous lipoma of the cecum that formed the starting-point of an invaginatio ileocæcalis.

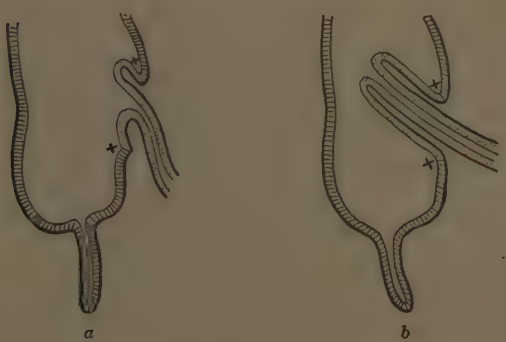

FIG. 361.—*a*, PROLAPSUS ILEI; *b*, INVAGINATIO ILEOCOLICA (H. Lorenz).

Hochenegg thinks with reference to carcinoma that it can become the cause of invagination only when it is polyp-like, or when it proceeds from the ileocecal valve.

Deichert describes a case of lymphocarcinoma of the digestive tract with multiple intussusceptions, while Luboff mentions a solitary lymphocarcinoma located at the point of the intussusceptum. A melanotic carcinomatous metastasis was described by Marchand as the cause of an intussusceptio jejunalis, the recurrence having taken place in the intestinal mucosa.

Meckel's diverticulum has repeatedly been the cause of intussusception. O'Connor reported the interesting case of the spontaneous elimination of a piece of intestine 22 cm. long from an intussusceptio iliaca, a

part of the intestine containing a Meckel's diverticulum. One of the rarest cases of this kind was reported by Golding-Bird, a four-weeks-old child presenting from the navel a prolapse of reddened mucous membrane from which feces were discharged. The prolapse increasing, the child died. The autopsy confirmed the diagnosis of intussusceptio iliaca, occurring through an open Meckel's diverticulum. Kuettner describes a case in which the diverticulum was itself the subject of intussusception. He states that his is the only case subjected to clinical study, the others reported having been noted only by the pathologists.

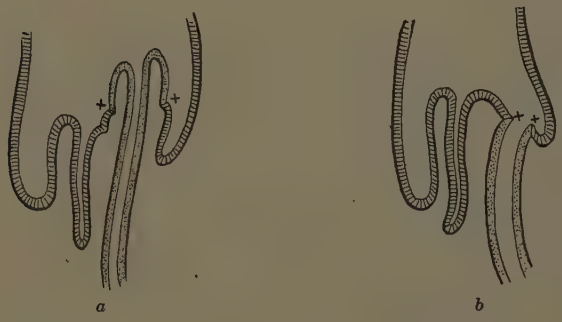

FIG. 362.—*a*, INVAGINATIO ILEOCÆCALIS IN CONNECTION WITH PROLAPSUS ILEI; *b*, INVAGINATIO CÆCOCOLICA (H. Lorenz).

The vermiform appendix may act like a Meckel's diverticulum in the cause of intussusception. Pitts described a case in which a chronic ileocecal intussusception involved the complete inversion of the appendix in a two-and-a-half-year-old child. The inverted vermiform appendix appears to have acted like a polyp, partly by traction. Waterhouse discovered a stone in the appendix which had been inverted into the cecum and had undergone intussusception.

Ulcers of the bowel have been found as causes of intussusception in dysentery and tuberculosis. In Orton's case a fifty-eight-year-old man was ill of chronic ulcerative "typhlitis." The correctness of the diagnosis was established at post-mortem, and moreover an intussusceptio cæcalis was discovered which had developed some time before death.

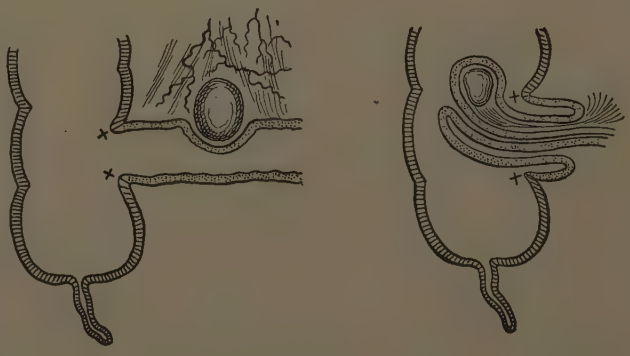

FIG. 363.—INVAGINATION CAUSED BY A LYMPH-GLAND (H. Lorenz).

Dartiques describes a case of mucous colitis complicated with invagination.

Fischl mentioned a case in which the end of an enema tube produced

a depression in the wall of the intestine that formed the starting-point of an intussusception.

Wiggin considers that trauma may play an important rôle in the intussusceptions of children, even the careless manner in which children are lifted and carried being sometimes an etiologic factor. Sudden strong movements of the muscles, as in coughing, and even the massage of the abdomen, may produce invagination in young children. More severe traumas, as falls from a height or the violence of foot-ball playing, may start invagination.

Gibson regards phimosis or narrowing of a stricture of the urethra as of importance in children, especially in the etiology of intussusception.

Schmidt reports the case of a man upon whom a resection of the pylorus was done, followed by gastroduodenal anastomosis by Murphy's button. A few days after the operation the patient, who was forty-eight years old, suddenly was seized with severe colicky pains, the cause of which was not known until the twenty-fourth day after the operation, when an intestinal slough was discharged, consisting of a part of the transverse colon which had been adherent to the greater curvature of the stomach.

Increased peristalsis apparently producing intussusception has been noticed by a number of writers as having been caused by a change of diet, especially in nursing children.

FIG. 364.—*a*, ENTRANCE TO ILEUM; *b*, *b*, SOUND THROUGH THE APPENDIX; *c*, VALVULA BAUHINI (H. Lorenz).

Clubbe[23] reports 100 cases of laparotomy for intussusception in children with 63 recoveries and 37 deaths. In the ileocecal form of the disease, which affected 64 patients, 43 were cured, 21 died. In the ileocolic form, of 12 patients, 7 recovered and 5 died. In the double form 20 patients were operated upon with 11 recoveries and 9 deaths. In the colic form 3 patients yielded 2 recoveries and 1 death, while in the enteric form one patient was operated upon with death.

If the disease apparently occupies a position on the transverse or descending colon, the median line is used for the incision; but if the mass is upon the right side, Clubbe makes the incision there.

The mortality of intussusception after operation has been studied by Wichmann.[24] Of 724 cases, 223 were operated upon: 73 recovered and 150 died.

Treatment.—No operation for intussusception can be considered complete unless those morbid changes which preceded the invagination, and which perhaps bore a causative relation to it, have been remedied or removed. Lorenz[21] lays especial stress upon the removal of polypi and Meckel's diverticulum, while in the case of the cecocolic form of the malady, an approximately normal fixation of the cecum and the ascending colon is to be provided. The well-known frequency with which recurrence of invagination takes place when once the accident has occurred makes this precaution one to be neglected only in cases of extreme urgency, where the prolongation of the operation for a few moments would be attended by a hazard disproportionate to the expected benefits of the procedure.

The **symptoms and course** of the disease correspond with those of other forms of acute, internal strangulation. In children, often following a trauma of the abdomen, the difficulty begins suddenly, especially in cases involving the small intestine, with severe colicky pain followed by vomiting and frequently by a bowel movement. A valuable diagnostic sign is the passage of muco-hemorrhagic material, occasionally in a diarrhea-like way. The discharge of small quantities of gas and feces may indicate that the intestine is not wholly occluded. Under these distressing conditions collapse frequently occurs in children. Meteorism is more likely to be pronounced where the occlusion is complete, but this symptom is uncertain as to constancy.

A palpable tumefaction occurs very frequently. Its size varies from that of an egg to that of a large section of the bowel. The shape is most suggestive of its origin; it is usually cylindrical, sausage-like, and often somewhat curved. But it is only in unusual cases that all the characteristics can be made out accurately. Though the resistance offered by the tumefaction is variable, it is usually to some extent yielding to pressure. It is best to examine during an attack of colicky pain.

Leichtenstern states that the most frequent site of the tumefaction is in the sigmoid region, then in the rectum, in the cecal region, and with diminishing frequency in the regions of the descending, transverse, and ascending colons and in the hypogastrium. The mass is not always found in the part of the abdomen normally harboring the affected intestine.

Strangulation.—Obstructions similar to those produced in strangulated hernia are due to: (1) The action of peritoneal products; (2) to that of Meckel's diverticulum; (3) to incarceration in adventitious rents or holes; and (4) to the strangulation of internal hernias (Nothnagel).

In the first category are to be included strangulations by isolated peritoneal bands due to antecedent peritonitis, which vary within wide limits as to site, breadth, length, thickness, strength, and points of attachment. All sorts of parts and organs may be bound together and the utmost variety of changes in the bowel may result from their con-

traction or from the engagement of the bowel beneath or about them.

The vermiform appendix, Meckel's diverticulum, or the omentum may become more or less fixed by adhesions and give rise to strangulation by permitting the bowel to become caught beneath them.

Congenital openings in the omentum and mesentery occasionally permit a loop of bowel to enter and become occluded. Adventitious openings due to productive peritonitis are common sources of such trouble.

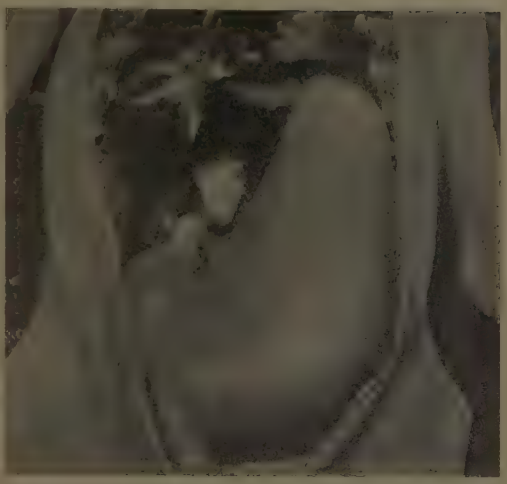

FIG. 365.—THE DILATED STOMACH DUE TO MESENTERIC OBSTRUCTION OF THE DUODENUM (Conner).

The extensive group of "internal hernias" has been treated elsewhere. (See page 99 in this volume.)

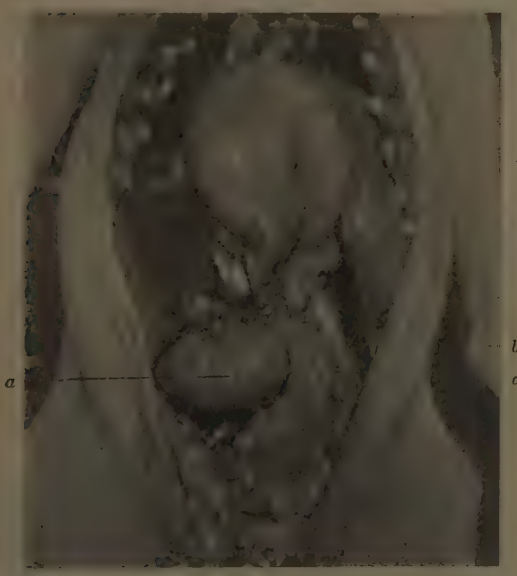

FIG. 366.—VIEW OF SAME CASE AFTER THE STOMACH HAD BEEN TURNED UPWARD AND THE TRANSVERSE COLON REMOVED (Conner).

Showing the greatly distended duodenum, the constricting root of the mesentery, and the collapsed first portion of the jejunum. *a*, Dilated duodenum; *b*, root of the mesentery; *c*, collapsed jejunum.

The symptoms are much like those of strangulation occurring in an external hernia—sudden pain following upon violent activity, then vomiting, with complete cessation of passages of gas and feces, feculent vomiting, collapse, perhaps some abdominal tenderness and death.

The diagnosis under these circumstances is based upon the same considerations as those upon which we make our diagnosis of strangulated hernia except for the absence of the externally demonstrable hernia. The site of the obstruction is usually to be determined only after opening the abdomen, which is, of course, strongly indicated.

Volvulus or axial rotation is the twisting or turning of a part of the bowel about its axis, obstruction to the fecal current resulting.

FIG. 367.—ANOMALOUS COURSE OF THE FIRST PORTION OF ASCENDING COLON (W. Wayne Babcock).

Unusual course and dilatation of the omega loop. Trilobed stomach.

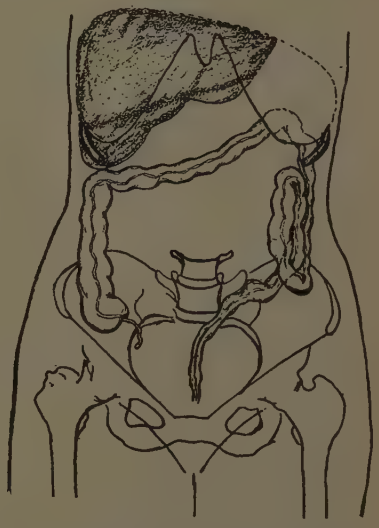

FIG. 368.—THE SIGMOID LOOP TOUCHES THE LOWER BORDER OF THE LEFT KIDNEY (W. Wayne Babcock).

Enlarged liver with marked transverse furrow.

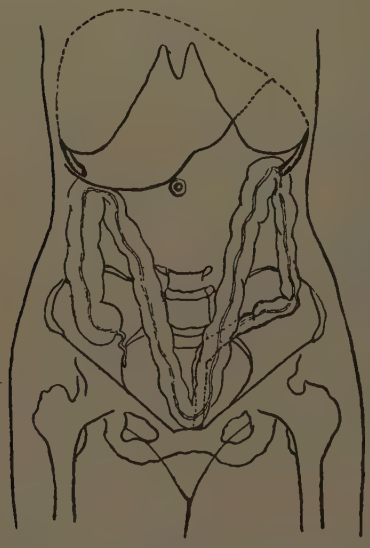

FIG. 369.—EXAGGERATED V-SHAPED COURSE OF THE TRANSVERSE COLON (W. Wayne Babcock).

The liver is enlarged from a fatty infiltration.

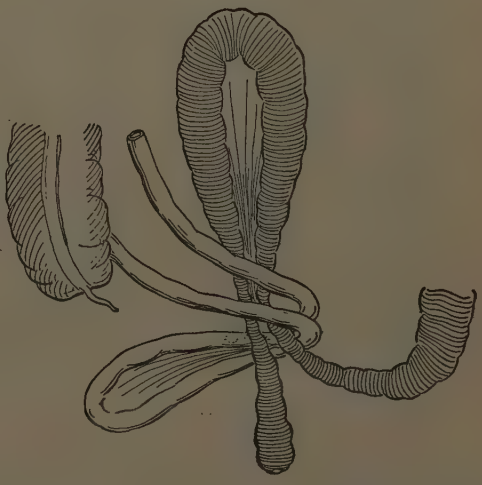

FIG. 370.—THE ILEUM PASSES IN FRONT OF THE ROOT OF THE FLEXURE AND EMERGES BEHIND THE ROOT OF THE FLEXURE TOWARD RIGHT. FLEXURE SHADED (Wilms).

The term volvulus is also used to designate knotting of the intestines. Rokitansky classified the anatomic possibilities as follows:

1. A loop may undergo occlusion by making a half or a whole turn about its longitudinal axis.

2. The entire mesentery or a section of it may rotate, with its associated bowel loop, a half or several times about its axis. This results in rotation about the mesenteric axis.

3. A loop of bowel with its mesentery may constitute the axis about which another loop with its mesentery may be turned.

The sigmoid flexure, owing to the peculiarities of its attachments, is the part by far the most frequently affected in volvulus.

Volvulus occurs more frequently in men than in women, and is typically a malady of the later years of life, being rare before the fortieth year. It is not often found affecting the small intesteine, though in the presance of bands and other adhesions it has been noted.

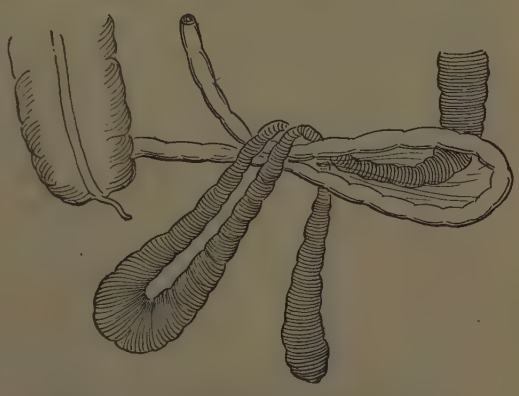

Fig. 371.—Knotting of the Intestines (Wilms).

Knotting of the bowels depends, like volvulus, upon the presence of a long mesentery with a narrow base, giving the two loops great freedom of movement.

The onset of the symptoms of volvulus is sudden, since they are due to strangulation, and often follows a quick and violent physical effort. The symptoms are then those of acute strangulative obstruction—pain, vomiting, absence of bowel movements, feculent vomiting, and collapse followed by death.

DIVERTICULA.

Meckel's Diverticulum.—Meckel's diverticulum was first accurately described by the anatomist of that name in 1808 as a part of the ductus mesentericus which had not undergone the usual regressive process. As a rule, it communicates with the lumen of the bowel, sometimes having a sort of valve at its outlet. It varies in length from 2 to 25 cm. and is situated from 4 cm. to 4 meters above the ileocecal valve, the usual site being between 30 and 90 cm. from that structure. Subject to a great variety of permutations of structure, it may be situated upon the free border of the bowel, though usually the opposite is the case. It may have a broad or a narrow base, may end blind or in a conical projection, and may even be dilated in the form of a sac. Remains of the obliterated blood-vessels may cause a splitting of the end into a sort of terminal ligament. Not infrequently it forms part of the contents of a hernial sac.

Its structure corresponds closely to that of the intestinal wall. The frequency with which this diverticulum occurs is from 1 to 2 per cent., the greater number being found in male bodies.

Various morbid anatomic changes occur in Meckel's diverticula corresponding to its normal anatomic structure. The analogy of the diverticulum to the appendix vermiformis is pronounced and is to be followed in the diseases of the two structures. Typhoid ulcers, catarrh, and perforative or gangrenous inflammation are not infrequently noted.

This very analogy makes it practically impossible to diagnosticate lesions of Meckel's diverticulum, and they can be diagnostically suspected only when the site of inflammation is near the umbilicus.

FIG. 372.—MECKEL'S DIVERTICULUM (Bunts).

Where Meckel's diverticulum is responsible for an intestinal disturbance elsewhere it is better to remove the sac by excision and enterorrhaphy.

Diverticulitis.—Acute diverticulitis is a term applied to an acute inflammation of both congenital and acquired diverticula, the former term almost always referring to Meckel's diverticulum and the latter to all diverticula arising in later life along the intestinal canal.

Inflammation of Acquired Diverticula.—It is only since 1899 that this subject has assumed clinical importance. Previously, acquired diverticula were looked upon as pathologic curiosities. Sidney Jones (1858) was probably the first to draw attention to their pathologic importance. He described a case of intestino-vesical fistula which he believed

to be due to ulceration of a sigmoid diverticulum. Loomis (1877), Birch-Hirschfeld (1887), and Biggs (1894) also reported cases. Beer, in 1904, classified and studied our knowledge upon the subject, while the clinical papers of Brewer and Mayo, read before the American Surgical Association in 1907, fixed it as a surgical entity to be considered in dealing with lesions of the left iliac region. We now have records of about thirty authentic cases available for study and many more in which the diagnosis is probable. The pathologic lesions are much more common than the case reports in the past would indicate.

Anatomy and Development of Acquired Diverticula.—The old classification of true and false diverticula should be abandoned. We now know that the so-called false diverticula may be provided with all of the coats of the intestine, as is the case with the congenital or so-called true diverticula. They are not produced by a protrusion of the mucosa between the muscular coats, as was at one time believed.

Acquired diverticula are found in the small intestine, appendix, colon, and especially the sigmoid flexure and rectum. In number they vary from few to hundreds. According to Gordinier and Sampson, acquired diverticula were found sixty-four times in 8132 autopsies at the hospital of the city of Dresden and nineteen times out of 2600 autopsies at Johns Hopkins Hospital. They may arise from any part of the surface. In the small intestine they are more often found near the mesenteric attachment, while in the large intestine there is no site of predilection as to the circumference. They are rarely larger than a walnut and generally are about the size of a pea or chestnut. They may be only microscopic in size.

Much study and experimental investigation upon cadavers and dogs has been carried out by Klebs, Heschl, Hanan, Good, Chlumsky, Graser, Beer and others with the idea of determining the pathogenesis, but without definite results. It is probable that diverticula arise frequently in relation to the veins and their sheaths, especially in the mesenteric type. While intra-intestinal pressure due to constipation probably has something to do with the development of those in the sigmoid, it is also probably true that there is some underlying loss of tone in the muscular wall which favors both the constipation and diverticula-formation.

Pathology.—Diverticula of the small intestine and appendix seldom give rise to clinical symptoms. Almost all of the reported cases have been connected with the sigmoid. The atrophic mucous membrane and wall of the diverticulum being pressed upon by hard fecal masses become ulcerated, and either rupture of the wall ensues or localized inflammation develops. These two processes give rise to two distinct clinical pictures. Following a perforation we may have a generalized peritonitis or an abscess. The latter, if untreated, frequently becomes closely adherent to the bladder and may perforate it. The localized inflammation, on the other hand, gives rise to marked connective-tissue growth, secondary cicatricial contraction, and consequent stenosis of the bowel. Rotter and Mayo have shown that these stenoses are produced by chronic inflammatory processes in the deeper layers of the gut wall and not by cicatricial contraction

of the mucosa. The mesentery also is frequently thickened. Thus the differentiation from carcinoma is impossible without a microscopic examination. To this latter type Wilson (Mayo) suggests that the term peridiverticulitis should be applied.

Etiology.—The majority of the patients are over fifty years of age. They are frequently obese and generally give a history of constipation. Hardened feces probably favor the ulceration.

Symptoms.—Peridiverticulitis gives rise to all the symptoms of stenosis of the sigmoid, associated with pain in the left side, and a mass which is tender, hard, and irregular. The patient is frequently anemic and has lost weight. Thus we see that the differential diagnosis from

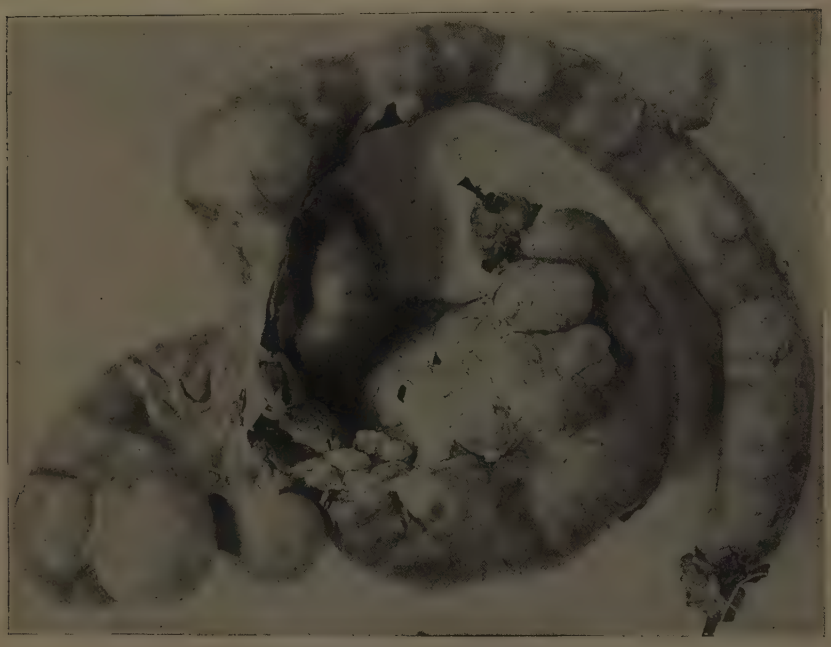

FIG. 373.—HODENPYL'S SPECIMEN OF MULTIPLE ACQUIRED DIVERTICULA OF THE COLON (SIGMOID FLEXURE) (Brewer).

carcinoma is almost impossible without exploratory incision and microscopic examination. These cases may be associated with fistulas involving the bladder or abscesses in the mesentery.

Diverticulitis associated with rupture may be followed by peritonitis, either local or general, and consequently gives the symptoms and signs of these conditions. If an abscess forms, it lies in the left inferior quadrant of the abdomen. The involvement of the bladder in these cases occurs with sufficient frequency to cause comment. No less than seven of the twenty-four cases mentioned by Beer and Mayo had a fistula connecting the gut and bladder.

Differential Diagnosis.—The diagnosis must be made from car-

cinoma, actinomycosis, tuberculous peritonitis, chronic sigmoiditis, left-sided appendicitis, and, in the female, adnexal disease. Preparation should be made for a frozen microscopic section in any suspected case, since in the more chronic cases the diagnosis may be impossible without it.

Treatment.—Abscesses should be drained and the opening in the bowel closed at the time of operation, if possible. If the bladder is involved, the organs should be separated and closed after the usual methods. If the stenosis has given rise to intestinal obstruction, an inguinal colostomy may be indicated, since owing to the age of the patient extensive operation may be contraindicated. It is probable that many of the supposed carcinomata that have been treated by this method, permitting the patient to remain well for years, were really cases of perisigmoiditis. If the patient is in good condition, resection of the bowel may be done. Out of five cases in which a resection was done by Mayo, three recovered.

FIG. 374.—PERIDIVERTICULITIS (W. J. Mayo, Wilson, and Giffin). Sketch of diverticulum with inflammatory deposit in subserosa. (xi diam.)

It is probable that as the condition is better understood this mortality can be reduced; if not, palliative operations will be indicated, such as an inguinal colostomy and closure of the distal end.

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PROPERTY OF SURGICAL OFFICE NOT TO BE REMOVED

Inflammation of Congenital Diverticula.—As has already been stated, when we speak of congenital diverticula of the intestine we generally refer to Meckel's diverticulum. Cahier has recently studied the subject and classifies the diverticula of the intestine as follows: (1) Diverticulum of Meckel; (2) ancestral diverticula; (3) diverticula by inclusion; (4) false diverticula.

The fourth class has already been discussed. The differentiation of the other three types is made by Cahier as follows:

1. **Diverticulum of Meckel.**—These are single, placed at the lower end of the small intestine, have the four coats of the intestine, are generally greater than 2 cm. in length (Heresco reports one 25 cm. long), may have a direct connection with the umbilicus or neighboring zone, or may be united indirectly by vascular bands with the mesentery, intestine, or umbilicus. When the filum terminale which unites it to the umbilicus is absent, the remains of it may be found at the end of the cul-de-sac.

2. **Ancestral Diverticula.**—These are conical or cylindrical, often shaped like the finger of a glove; generally lying on the lower half of the small intestine, but sometimes higher, on its free border. The length of these diverticula is variable; not less than 2 cm. While generally free, they may have a small mesentery or may present acquired adhesions with the abdominal wall or other viscera. They may be multiple and they have no filum terminale. These are developmental anomalies of an ancestral nature analogous to the appendages which one finds in many animals, as rabbits, cats, and birds, being produced by a sort of budding process like that which gives rise to the cecum and appendix.

3. **The Inclusion Diverticula (Diverticules Enteröeides par Inclusion).**—These are rare, and are found in the lower end of the ileum. They are about the size of an almond or walnut, with a pedicle of moderate length, which may be entirely absent. It occupies the free border of the intestine and lacks a filum terminale. This should be regarded more as a subserous cyst, probably related to the vitelline duct, lying in the wall of the gut. In Tiedmann's case there was only a small opening into the bowel, through which a probe could be passed. These two latter types, and others which have been suggested by other authors, cannot as yet be considered as fully accepted. For clinical purposes all congenital diverticula can be considered under the same heading with Meckel's.

Development of Meckel's Diverticulum.—The malformation known as Meckel's diverticulum was first described by Ruysch. Meckel was first to explain its origin from the vitelline duct and call attention to its presence as a frequent cause of disease. It is present in from 1 to 2 per cent. of all bodies. Richter discusses its development as follows:

"With the closing in of the abdominal plates, the connection between the vitelline sac and the cavity of the primitive intestine becomes reduced to a tubular structure, the vitelline duct, continuous at one end with the convexity of the U-shaped primitive gut, at the other with the vitelline sac. The structure of the wall of the duct is, of course, identical with that of the wall of the primitive intestine. During the further evolutionary changes the duct, during the second month, becomes reduced to a mere

thread, with finally a complete solution of continuity between vitelline sac and gut. No traces of duct are present in the bowel-wall of fetuses of four to six months or in the cord by the end of the sixth month. Cell groups found in the cord at term, and believed by Ahlfeld to be the vitelline remains, are considered allantoic remains by Minot.

"Accompanying the duct are its vessels, the arteries arising in the primitive aorta and passing along the duct to the vesicle, the veins returning to empty into the mesenteric vein. Retrogressive changes in duct and vessels should be synchronous.

"The primitive gut is first an intra-abdominal organ. Traction by the vitelline duct results in a hernia of the gut into the base of the cord, beginning at the end of the first month, reaching its maximum toward the end of the second month—fifty-third day (Minot)—when, with the giving way of the duct, gradual reduction of the hernia and complete closing in of the ventral plates take place. During the further development of the U-shaped primitive gut the relative growth of the two legs is such that the insertion of the duct is in the lower portion of what becomes the ileum, with, however, so much variability in exceptional cases as to be placed at almost any part of the small intestine, from the lower end of the duodenum to its cecal end.

"Deviations from the normal in the evolution of the vitelline duct result in malformations that may be grouped in two quite different types of congenital malformation: (1) that represented by congenital diverticula and their remains, congenital bands, etc.; and (2) that represented by congenital hernia into the cord."

Besides the pathologic processes, such as obstruction due to the filum terminale looping about a bowel, etc., and strangulation in a hernial ring and intussusception, the diverticulum is subject to inflammation arising from various causes within itself, presenting a clinical entity to which has been given the name of diverticulitis.

Porter has collected and classified one hundred and eighty-four cases in which the diverticulum was the cause of severe intestinal symptoms, and the relative proportion of diverticulitis to other conditions is shown by the following table:

Obstruction in a hernia	21 cases
Obstruction by band	101 "
Volvulus	8 "
Intussusception	20 "
Patent at umbilicus	5 "
Diverticulitis	17 "
Perforation in typhoid	5 "
Tubercular ulceration	2 "
Prolapse of bowel	2 "
Pelvic tumor	1 "
Rupture of diverticulum causing obstruction from pressure of abscess	1 "

Males.....100 Females.....30

Average age, twenty-one.

Historical.—Körte, in 1894, classified the symptoms of diverticulitis. At an earlier date, however, Richa, a surgeon of Turin (1721), noted after

death the presence of the diverticulum in certain cases which had complained of colic during life. Duvignand (1786) made the same observation. Rayer (1824) recognized at necropsy an inflamed and gangrenous appendix on the ileum of a patient who had suffered from gastro-intestinal colic, and Denucé, in 1851, observed a perforation of the diverticulum produced by a cherry-pit.

Etiology.—Cahier has studied thirty-five cases, and of these, sixteen occurred in men of from twenty to fifty-eight years of age, three in youths of eighteen years, ten in infants, and six in women from twenty to forty years of age. Digestive disorders are often mentioned in the preceding history. The perforation of the diverticulum through a typhoid ulcer has been reported in at least six cases; that is, one-sixth of the reported cases of diverticulitis—a proportion worth noting. In two cases a perforation due to tubercular ulceration was found. We should note also that the fixation of the one end by either congenital or acquired adhesions favors the production of a torsion which may lead to gangrene of the diverticulum or obstruction of the bowel due to inflammation or kinking. Watkins, in 1893, reported a gangrenous and perforated diverticulum due to torsion. It should be noted also that the wide-open mouth with a long diverticulum favors the lodgment of feces, giving rise to coproliths, and the retention of foreign bodies which may enter. These have been found in nine cases—twice apple-seeds, four times cherry-stones, three times coproliths. Twice sharp particles like pieces of fish-bone have caused perforation and abscess. Holbeck noted ascarides in an abscess and Escher found small intestinal worms in another case. Trauma may also be a factor, since we are dealing with an organ which may be filled with no outlet at one end, hence favoring rupture on an increase of pressure. This danger is accentuated, since it is frequently fixed to the umbilicus or other structures at one end.

Pathology.—The morbid anatomy varies with the etiologic factor, whether it be a perforation, torsion with gangrene, or other associated conditions. The organ undergoes the changes incident to like inflammation in other parts, and a description of the folliculitis, perifolliculitis, round-celled inflammation ending in regression, gangrene, plastic adhesion to other organs, or generalized peritonitis is unnecessary. The perforation frequently is found on the apex of the diverticulum. In the chronic cases adhesions to any organ may be present, but they are frequently found in the right iliac fossa. Several cases are reported of strangulation in hernial sac. Richter has reported a unique case in which there was a diverticulitis in an inguinal hernia without any evidence of strangulation by the ring.

Symptomatology.—An accurate classification of the various types is impossible. Clinically, however, we may divide the cases into: (1) Fulminating, (*a*) without previous history, (*b*) with previous history; (2) subacute; (3) chronic.

The fulminating type comes on suddenly, like any acute abdominal crisis, and early it is impossible to diagnosticate it from similar lesions. A torsion of the diverticulum gives the history, symptoms, and signs of

an acute appendicitis, not located, however, at the proper site. To this picture is soon added those of intestinal obstruction, either from twisting or kinking of the gut or a paralytic ileus. If a perforation be present, we have the pain, tenderness, collapse, and the succeeding signs of peritonitis characteristic of that lesion elsewhere. Frequently there is a history of previous attacks, as will be discussed under the chronic type.

The Subacute Type.—At times we meet cases in which there has been a history of a distinct attack such as we have already mentioned. Instead of leading to a generalized peritonitis, however, the process may end in a localized infection about the diverticulum, presenting either abscess formation or plastic adhesions. More or less tenderness is present for some time, associated with gastro-intestinal symptoms, just as in a subacute appendicitis. The abscess ruptures into the intestine or, as in one case reported, into the bladder. The adhesions remain either temporarily or permanently and may give rise to intestinal obstruction in various ways.

The Chronic Type.—In about a fourth of the cases reported the patients had complained of previous gastro-intestinal symptoms, often constipation and indefinite pains in the right paraumbilical region. This picture is made complete by intermittent attacks of acuter pains and tenderness corresponding with exacerbations of the local inflammation and paralytic ileus, or temporary strangulation of the diverticulum. The patients of Cahier, Galeazzi, Italo Antonetti, Jackson, and Hilgenreiner showed two, three, and more such typical exacerbations before the final fulminating attack.

Prognosis.—Owing to the fact that up to the present time no cases have been operated upon except in the presence of the acute attack, the mortality has been high—eleven out of twenty-three cases died. With a better understanding of the conditions and with earlier diagnosis and operation, the mortality should be lessened.

Diagnosis.—The diverticulitis is most often mistaken for appendicitis and intestinal obstruction. The differentiation is most difficult. The signs which should attract the attention of the surgeon are: (1) the localization of the tenderness above and inside of McBurney's point, or even in the median line below the umbilicus; (2) rigidity in the same region; (3) the presence of blood in the stools, often only found on microscopic examination; (4) the existence of an umbilical fistula or other congenital malformations. These signs are not at all definite and might easily be present in inflammation of an aberrant appendix. Between an intestinal obstruction and an inflamed diverticulum the diagnosis is difficult. On the one hand, we have the evidences of obstruction most marked; and, on the other, those of intra-abdominal inflammation, with the localized tenderness, temperature elevation, and rigidity.

Treatment.—The treatment is that of any severe intra-abdominal inflammation, the complications being dealt with by removal of the diverticulum, the production of a fecal fistula, and the drainage of a localized abscess or treatment of a generalized peritonitis as the condition may demand. The removal of the diverticulum should be done by the usual

methods of intestinal suturing. Manchalrie has suggested invaginating it, but the danger of a sequential intussusception is much increased by this procedure.

INTESTINAL FISTULA.

An artificial opening through the skin and the intestines so that the intestinal opening communciates with or directly joins the skin opening may be intentionally produced or be of accidental origin.

Those produced intentionally, as a rule, are so made that subsequent efforts to close them can be carried out with ease and precision. Senn[26] has classified accidental fistulas as produced by gunshot and stab wounds of the abdomen, subcutaneous injuries, ulcerations, strangulations, intestinal foreign bodies, malignant tumors, intestinal actinomycosis, abscesses, appendicitis, accidental operative injuries, ligatures, sutures, and drainage-tubes.

All of these etiologic factors can result in the formation of these fistulas, provided the intestine becomes adherent to the abdominal wall by plastic inflammation before a general peritonitis takes place with a fatal result, and provided also that the requisite openings in bowel wall and skin are produced by ulceration or by trauma.

The **morbid anatomy** of these lesions is of considerable importance from the point of view of treatment.

At the outset granulations, as a rule, line the tract from the level of the skin to the mucous membrane of the bowel, while later, as a rule, the two epithelial surfaces may have been rendered continuous by proliferation of the epithelium in both directions. Moreover, the element of obstruction at or below the artificial opening is of great importance. If the bowel is drawn up to the abdominal wall sharply and from a considerable depth, a bend or flexure must occur, making it necessary for the fecal current to pass around a sharp corner or spur, favoring the extrusion of gas and fluid by the artificial rather than by the natural passage.

A so-called spur may be produced when both afferent and efferent limbs of the coil involved are brought up into a wound, and where the mesenteric part of the bowel becomes adherent to the peritoneum or other structure of the abdominal wall. In this case it is necessary that the fecal matter shall first pass out upon the skin.

A third class of obstructions are those that lie below an artificial anus or fistula, and these may, of course, be of any imaginable origin.

Treatment.—Fistulas of the intestine upon the skin are almost always amenable to very simple treatment. Cauterization of the tract, where epithelium has not formed, may be effected by the use of chemicals, such as silver nitrate. The actual cautery may be required if epithelium has formed. The chances of success are greatest where no epithelium lines the tract and where the artificial tube is long and narrow.

If a mechanical obstruction exists, it is often necessary to relieve the impediment to the fecal circulation. A flexion or spur may be treated by the old enterotome of Dupuytren or its modified and improved form as given us by Blasius. This instrument has for its purpose the forma-

tion of adhesions between parts of the bowels not previously agglutinated, but which nevertheless form part of the coil in question; and, in the second place, the destruction of so much of the walls of the bowel as will enable the feces to pass by a deeper and more direct route from above downward. The uncertainties and dangers of the instrument in application to these cases are obvious.

It is far better under most conditions to resort to a plastic operation

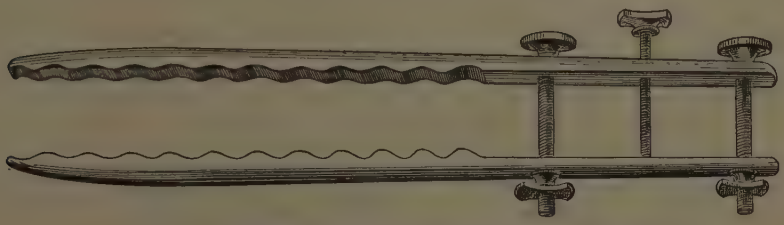

FIG. 375.—DUPUYTREN'S ENTEROTOME.

for the closure of the opening. Attempts may be made to close the fistula by suturing the intestinal wall without opening the peritoneal cavities. These attempts, however, are as a rule unsuccessful, on account of the presence of so much infectious matter. The stitches slough out, the pressure of intestinal contents overcomes the resistance of the weak, new connective tissue, and the fistula is re-established.

Intestinal anastomosis with the exclusion of the part involved may be employed, but only in extraordinary cases, where simpler, more direct methods are applicable.

Resection of the bowel with re-establishment of its continuity after opening the free peritoneal cavity must in future be limited to very exceptional cases.

We agree with Senn that the method suggested by him will obviate the necessity of resorting to these graver procedures except in the most extraordinary cases.

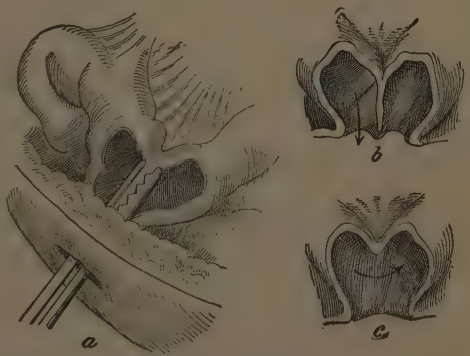

FIG. 376.—TREATMENT OF ARTIFICIAL ANUS BY DUPUYTREN'S CLAMP (after Esmarch).

a, Enterotome applied; *b*, the spur in section; *c*, bowel after removal of spur.

The procedure of preliminary transverse suturing can readily be understood from a reference to the illustrations. Only so much of the edge of the bowel opening is loosened as will permit the operator to apply a strong layer of transverse sutures in such a manner that the contents of the bowel may not flood the field of operations. The abdominal cavity may then be opened after careful cleansing, the bowel thoroughly

detached from the abdominal wall, and the additional sutures buried by successive layers of Lembert stitches. Should it be difficult to obtain good surfaces of peritoneum with which to cover the line of sutures, it would be admissible to use a part of the omentum or portions of the parietal peritoneum, depending upon the location of the fistula.

INTESTINAL CYSTS.

Among the rarer intestinal tumefactions are the intestinal cysts. They are for the most part congenital in the small intestine, while in the

FIG. 377.—INTESTINAL CYST (Gfeller).

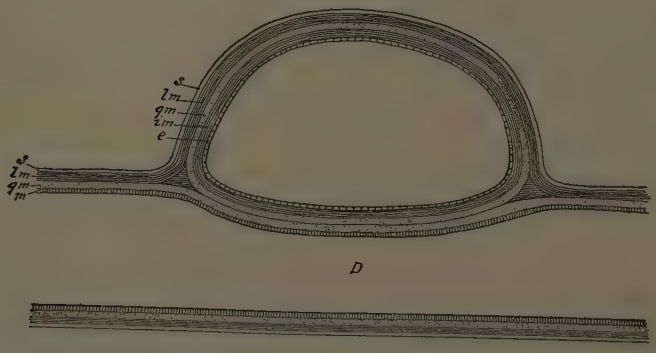

FIG. 378.—LONGITUDINAL SECTION OF INTESTINAL CYST (SCHEMATIC) (Gfeller).
c, Lumen of cyst; *d*, lumen of intestine; *s*, serosa; *lm*, longitudinal muscular layer; *qm*, circular muscular layer; *im*, inner muscular layer; *e*, epithelial coat of cyst; *m*, intestinal mucosa.

large intestine, as a rule, they are acquired following an inflammatory process in the mucosa, as, for example, in dysentery.

Gfeller has given especial attention to the congenital cysts, which in the majority of cases take origin in persistent relics of the irregularly obliterated ductus omphalomesentericus, whether this be by the separation of a part of the intestinal tube anlage or by germinal displacement.

Corresponding to this varied anatomic origin it is easy to see that the walls and contents of these cysts may vary within wide limits. We may have all the appearance of a dermoid, on the one hand, or, on the other hand, simply thin-walled mucus-containing sacs.

The **diagnosis** was not made in any of the observed and recorded cases, since these cysts do not present any characteristic clinical symptoms. Nevertheless it is true that irregularly recurring attacks of partial intestinal occlusions are known sometimes to have occurred, and these may suggest such a congenital anomaly as that in question.

The prognosis is not unfavorable except where the continuity of the bowel is impaired.

Treatment.—The treatment can only be by removal. A subserous cyst, of course, could be enucleated. If the cyst is intramuscular, as was the case in the instance observed by Gfeller, an enucleation may still be practised, though great care must be taken to apply Lembert sutures appropriately.

ADENOMATA.

Polypoid adenomata in the intestinal tract are relatively rare. They occur, however, in groups at any point from the stomach to the lowest limits of the bowels.

The **clinical phenomena** to which they give rise are variable, depending upon the size of the adenoma and the point of its location. In many cases no symptoms are present. In the small intestine even large adenomata may give rise to no signs owing to the thinness of the intestinal contents.

Severe hemorrhages may occur, however, and where sufficient size has been attained partial stenosis may take place. It is also well known that intestinal polypi may favor intussusception. In some instances a tumor may be found upon palpation, showing an extraordinary mobility. In the large intestine it may be possible to palpate the tumor directly by the introduction of the finger into the intestine. Multiple polypi may be thought of when there is continuous discharge of blood and mucus without the ordinary causes for such a discharge being available for its explanation. The disease is very chronic.

The **prognosis** is variable according to the nature of the case. General rules cannot be given. The best prognosis is given by those cases in which the polypus is solitary, especially if operative treatment can be adopted. The only satisfactory treatment is by excision.

RUPTURE AND CONTUSION OF THE INTESTINES.

Pathogenesis.—The study of the pathogenesis of rupture of the intestine is of great importance from a diagnostic standpoint. Before 1875 surgeons held that when traumatism occurred increased intra-intestinal pressure was the most frequent cause of rupture, but in that year Von Longuet showed by experiments that the crushing of the bowel at the moment of the shock was the most common factor.

Moty has suggested three forms of rupture: (1) the crushing (*écrasement*), (2) the tearing (*déchirure*), (3) the bursting (*éclatement*). The classification is most satisfactory. The largest number of cases fall under the first heading. The patient gives a history of having received a sudden blow in the abdomen. It is not necessary that the blow should be very severe, since all kinds of bodies have been known to inflict the injury, from the blow of a fist to more severe injuries. The injury may also be received by the patient moving against a fixed body. Voswinckel's cases received their injuries as follows: run over, two; horse kick, two; struck by tongue of wagon, four; caught between two wagons, two; fall, three; struck against corner, one. Ten times the patient was struck by the object and four times the patient was the moving body.

There is a difference of opinion between civil and military surgeons as to the frequency of rupture following horse kicks. Moty, Cahier, and Peck maintain that only about one-seventh of the patients kicked suffer from rupture, while surgeons in civil life find the proportion much higher, due doubtless to the fact that only those suffering severely consult the surgeon, while in the army every injury is recorded. An injury which is very constantly followed by rupture is that produced by boards thrown violently against the abdomen while being cut in saw-mills.

In Lund's nineteen cases the most frequent causes were, in order of frequency: (1) blows on abdomen by some thrown body; (2) blows on hernia; (3) horse kick; (4) falls.

The essential relation in the crushing type of injury is that the bowel is caught between the moving body, *e. g.*, hoof of the horse, and a fixed portion of the body, *e. g.*, the spinal column. It follows, then, that the blow must be sudden, so that the intestines will lack the protection which would normally be provided by the rigid abdominal wall. Eichel has demonstrated this fact by a series of experiments on dogs. In the first series, after having anesthetized the dog, he made the muscles rigid by extending the legs and was not able to produce a rupture by striking the dog on the abdomen. In the second series he overfed the dogs for two days and carried out the experiments under the same conditions as above, again with negative results. In the third series the hind legs were loosened so the abdominal wall was relaxed and rupture was frequently produced. It has been shown repeatedly that lean people with the intestines distended by food are more liable to rupture than others.

The part of the abdomen struck and the direction of the blow are also of considerable importance in making a diagnosis as to whether or not a gut is ruptured. Most surgeons believe that the region just below the umbilicus is the most dangerous zone. Moty, however, maintained that an area of about one-seventh of the anterior abdominal wall on a level with and just above the umbilicus was the zone of greatest danger. In this he is supported by Cahier, who has also studied the effect of the direction of the blow. A blow going directly back or one going obliquely from without, inward and downward, will crush the intestine between the moving body and the vertebral column, while one striking the median

line going down and out would be likely to injure the colon, but not the small intestine.

The second manner of injury is that in which the gut is torn from the fixed point. This occurs in patients who fall, not striking the abdomen but some other part of the body. The descent of the body as a whole is stopped, but the intestines continue to fall and are thus torn loose. Three factors are probably necessary for this injury: first, the abdominal walls must be relaxed; second, the gut must be loaded with heavy contents; third, the mesenteric attachment must be longer than its point of fixation. E. J. Senn reports such a case in a patient who slipped while walking and fell on his buttocks. Again, this injury may occur in falls or blows in which the abdomen is struck in an oblique direction; the glancing blow catching the intestine, tears it off at a fixed point. These points are most commonly at the beginning of the jejunum, the end of the ileum, and the sigmoid flexure at its junction with the colon.

The manner of rupture in the third class of cases where the lesion arises as a result of bursting from intra-abdominal pressure is not fully understood. Why we should have one part of an intestinal wall ruptured when there is the same force exerted on every side is hard to explain. It has been suggested (Petry, Sauerbruch) that it may occur as a result of closure of one or both ends of a loop, as by kinking, adhesions, tumor growth, or even the pressure of the moving body closing both ends when the legs of the loop lie side by side. The striking body then closes the other end and suddenly increases the tension in this loop. Again, it is suggested that the overdistended loop, holding the mesentery taut, is suddenly struck by the moving body in a centrifugal direction, thus tearing the loop away from its mesentery. Bunge suggests that the rupture occurs at the site of hernial rings and weak spots in the abdominal wall, as internal hernial rings, inguinal hernia, openings through the diaphragm, the rectal opening in the pelvis between the levator ani muscles, between the ileo-coccygeus and pubo-coccygeus (Lücker), between the ileo-coccygeus and coccygeus (Waldeyer). At these sites, the support of the wall being absent, all the intra-abdominal force would be exerted. There may be diverticula or ulceration in the wall of the gut favoring rupture.

Pathology.—Jalaguier, basing his claims on three hundred and forty-five cases, states that injury to the bowel occurs in one-eleventh of all cases of abdominal injury. Since the most frequent cause of rupture is that in which the gut is caught between the moving body and the spinal column, it follows that the ileum should be the part most often injured. In Lund's nineteen cases, eighteen were in the small intestine and one in the large; Voswinckel, fourteen cases—one in stomach, two duodenum, ten small intestine, and one in the large intestine; Chavasse, one hundred and forty cases—ileum and jejunum one hundred and six cases, duodenum seven, large intestine nineteen, large and small intestine seven, rectum one. In Curtis' collection of one hundred and thirteen cases, only four had injury to large bowel. We thus see that the large intestine is seldom injured. The infrequency of injury to the duodenum is also noteworthy. When tears occur here, they may be retroperitoneal, however, and be

discovered only at post-mortem. As has been mentioned, rupture from tearing most often occurs at the duodenojejunal junction. It is here that we find the cases of complete severance of the intestinal tube. Frequently, in addition to this, the mesentery is torn from the gut, so that the tube may be found free from any attachment for several inches. This same condition occurs to a less degree at the ileocecal and sigmoidorectal junctions. In the crushing injuries the wound may be small or large, is frequently irregular, but may be a straight wound, while in the bursting type the wound is generally round, as would be expected. The mucous membrane rolls out so as to nearly close the opening in the smaller wounds. This partial closure is aided by the contraction of the circular fibers of the gut above and below the wound, so that while the mechanical protection is not so great as in gunshot and stab wounds, it is often remarkable how little feces may escape even in severe injuries.

Multiple injuries are reported, but they are not frequent. In cases of injury from kick of a horse, the double injury has been attributed to the projections on the horse's shoe. Again, it has been claimed that one of the injuries occurred from bursting due to closure of both ends of the loop and pressure, and that the other is due to crushing. Yet another explanation is that two loops were caught at the same time, either parallel or superimposed.

Contusion of the bowel wall may occur without a rupture or we may have a separation of one or more coats. In the case of contusion there may be a considerable accumulation of blood beneath the mucosa, giving rise to hemorrhage into the bowel and at times to an extensive slough of mucous membrane. It is said that there is never a severe hemorrhage into the bowel in case of complete rupture, and this seems reasonable. There may be only a slight ecchymosis. Jobert reports a case in which there were ecchymotic areas on the bowel and a rupture of the longitudinal fibers. Poland reports two similar cases. Owing to these contusions as well as injuries to the mesentery, perforation may occur at a later date. Bryant has reported two cases of delayed perforation, one on the fifth day and another on the nineteenth day. Cases are reported in which peritonitis has developed where there was no demonstrable complete perforation. Courtois and Destrez operated upon a patient thirty-eight hours after injury and found a peritonitis with only a tear in the serosa of the large intestine. Petry has reported a similar case in a four-year-old child who was run over by a wagon.

When the mesentery is injured, it is more likely to lead to extensive gangrene than to single perforation. Rupture and tearing of the mesentery is a serious injury. There may be hemorrhage between the leaves or extensive tears. Neumann has studied the question and classifies the tears under two heads—(1) tears parallel to the gut, (2) tears perpendicular to the gut. The first type, which is naturally most dangerous, occurs most often with complete rupture of the gut at the duodenojejunal junction, but may occur at any point. It is more likely to occur when the distended gut has made the mesentery taut. The moving body strikes the mesentery at its junction with the bowel and either tears it

off or cuts it between the moving body and spinal column. Gangrene of the bowel nearly always ensues and extensive resection should be done.

The intestinal arteries injured in lacerations of the mesentery are the superior and inferior mesenteric or their branches.

The disposition of the branches of the superior mesenteric is interesting. These branches number from twelve to twenty, are long above, shorter below. They bifurcate so as to form two or three concentric arcades which approach little by little the border of the intestine. The last of these arcades furnishes the vessels of the intestines. The last branches are true terminal arteries. From this anatomic study we note that a wound of the secondary branch of the superior mesenteric far from the intestine does not, owing to the richness of the anastomosis, cause gangrene of the intestine, but if the branches are cut or injured near the intestines, gangrene will follow.

Labastic has studied the question by experiments on dogs. His results were as follows: Section of the superior mesenteric artery—gangrene of a long portion of the small intestine. Section 8 cm. along the border of the mesentery in such a way that all the recti vessels are divided close to the intestine—gangrene of the intestine for 4 cm. Incision of the mesentery 5 cm. from the mesenteric border of the intestine—plaque of superficial gangrene of the intestine. Incision 8 cm. from the mesenteric border of the intestine—intestine is not involved.

The closer these lesions are to the intestine, the more serious are their consequences. Besides the generalized and local peritonitis which may follow rupture, Schloffer has drawn attention to the presence of sequential stenosis due either to adhesions or to scar formation in the intestinal wall.

Associated with injury of the intestines we frequently find injuries of other organs. In Flint's twenty-one cases 45 per cent. had injuries to other organs; this percentage is higher than is usually found, however. Villemin has reported a case with hemorrhage into the rectus in front and the psoas behind. Voswinckel reports a case which developed a lymph fistula.

Symptoms and Diagnosis.—The symptoms of rupture of the gut are those of any severe abdominal injury. The diagnosis will always be in doubt, and must depend on the variable factors of the surgeon's judgment and experience supplemented by exploratory laparotomy in every suspected case. The diagnosis will depend largely upon the following: (1) history, (2) shock, (3) abdominal pain, (4) abdominal rigidity, (5) nausea and vomiting, (6) pulse, (7) signs of developing peritonitis, (8) exploratory laparotomy.

What will be said concerning these signs and symptoms can be only relative, since any of them may fail, and its absence should not deter us in making a diagnosis.

History.—The patient gives a history of a severe blow upon the abdomen coming so suddenly that the abdominal muscles have not had time to contract. The blow has probably been received in the "dangerous zone"—the mid-line above or below the umbilicus. While the patient may not have complained of great pain and shock immediately following

the injury, the history will probably be such a one. Kicks by horses and blows by the ends of boards should be looked on as especially dangerous.

Shock.—Shock is frequently severe, so that the question of intra-abdominal hemorrhage will come into consideration. The running pulse, semi-dilated pupil, cold extremities, subnormal temperature, clammy skin, the anxious look, irregular and gasping breathing, all suggest the presence of some severe lesion. Douboujadoux has described a peculiar coloring of the face at the nasolabial fold. On the other hand, patients with severe intestinal injuries have frequently gone about with little discomfort and no evidence of shock. The shock soon subsides and gradually passes over into the symptoms and signs of peritonitis. It is exceptional for the patient to become unconscious.

Abdominal Pain.—The pain is frequently severe, and while it is generalized it is almost always most marked at the site of the injury. Especially is it sensitive to pressure. There is the thoracic breathing present in severe abdominal trauma and inflammation. The patient lies upon the back with the legs drawn up. Tenderness may be noticed by rectal examination.

Abdominal Rigidity.—This is the most marked and characteristic symptom, and with tenderness is most commonly present. The wall may be retracted, but over the site of the injury there is a board-like rigidity. If the injury is on one side, the difference between this side and the uninjured side presents almost a pathognomonic sign. The recti often stand out, strongly contracted. As peritonitis develops the retracted abdomen is replaced by distention.

Nausea and Vomiting.—Voswinckel says that vomiting is present in nearly every case. Other authors place the percentage at 50. This, however, included the later hours. A few at least vomit at once on receipt of the injury. Lexer places especial stress upon the vomiting of bile. This latter, however, is not supported by others, except when peritonitis is present. Nausea at least is almost always present early.

Pulse.—The pulse is early that of shock and later of peritonitis. The pulse frequently is found to have a rapidity out of proportion to the shock apparently present.

Signs of Developing Peritonitis.—Patients should have been operated upon without waiting for these signs. If they have not, however, it is noted that the patient recovers from the shock. The cheek becomes flushed, the eyes sink, the restless rolling of the eyes and constant moving in bed are very conspicuous, the expression is anxious, the temperature begins to rise, the board-like rigidity of the abdominal wall gives way to distention by gas in the intestines, vomiting begins, soon becoming bile-stained and then fecal, the pulse rises and the tension increases, hiccup may develop. There may be a localized dullness at the site of the injury, where there may be an abscess or matting together of the intestines. The obliteration of the liver dullness by free gas is not now regarded as of as much importance as was once attributed to it. Brentano speaks of two cases in which a retroperitoneal hemorrhage gave all the symptoms of a peritonitis.

Exploratory Laparotomy.—An exploratory incision should be made in every suspected case when the proper facilities for operation are present. The test of the blood-pressure is of only relative importance, and the same may be said of the leukocyte count. The white blood-cells may or may not be increased, and the loss of blood is seldom sufficient in amount to cause any appreciable difference in the number of red blood-cells. If a stool is secured, microscopic blood may be demonstrated. Its absence, however, should not influence the diagnosis.

Prognosis.—The prognosis is not so good as in stab and gunshot wounds, owing to the large size of the wound, which is more likely to permit the escape of fecal contents, and also owing to the fact that the operative interference is not so prompt.

Petry collected one hundred and sixty cases treated expectantly with a mortality of 93 per cent. In one case the wound was closed by omentum and in ten there was local abscess formation. Of forty-two cases collected by the same author operated upon in the first day, fourteen recovered and eighteen died—66 per cent. Tawaststjerna collected one hundred and twenty-five cases with a mortality of 67.2 per cent. These statistics are hardly borne out by the complete statistics of individual authors, since fatal cases are not so frequently reported. Newmann operated upon twenty-one cases, one recovered; Thommen, ten cases, two recovered; Schmitt, eight cases, one recovered; Brehm, seven cases, one recovered; Mauclaire, five cases, one recovered; Wölfler, fifteen cases, thirteen operated upon, three lived. The time of operation is noted as follows: five in first twelve hours, two lived; four in twenty-four to thirty hours, two lived; four later, one lived. Thommen's cases were classified as follows: three operated upon in first five hours, one recovered; two in five to twenty hours, one recovered; two in twenty to thirty hours, none recovered; three in thirty to sixty-five hours, none recovered. Siegel collected three hundred and seventy-six cases with the following prognosis as to hours: In first four hours, mortality 15.2 per cent.; in five to eight hours, 44 per cent.; in nine to twelve hours, 63.6 per cent.; later, 70 per cent. We thus see how grave is the prognosis and how imperative it is to have an exploratory operation at once in suspected cases.

Treatment.—At least one of the earliest operations for rupture of the gut was performed in 1883 by Bouilly. To Moty, however, is probably due the credit of the first recovery following intervention, in 1889.

It being decided that operation is indicated, it should be performed as expeditiously as possible. No time should be lost by unnecessary delay. If shock is present, it should be vigorously combated by stimulants, transfusion, or enemas of normal salt. Crile's shock jacket may be applied. All scrubbing of the patient should have been done, he should be placed on the operating table and everything be ready before the anesthesia is begun. As little should be given as possible. Ether will probably be preferred, and should be preceded by nitrous oxid or some of the adjuvants to rapid anesthesia. The site of the incision should be as near the point of tenderness and bruising as is possible and yet remain near enough to the median line to permit of careful examination of the entire gut. The abdominal

opening should be large enough to allow the operator to work quickly and accurately. If the rupture is not seen at once, some fixed point is chosen, as, for instance, the ileocecal or jejunoduodenal junction, or a strip of gauze may be tied about the gut at the first loop picked up, and then the bowel should be carefully examined throughout its extent. The condition of the mesentery should also be noted. If the ruptured gut is found at once, it should be cared for first and then the gut examined. The rupture should be closed by transverse suture, so as not to impair the lumen of the bowel. The closure should be by the usual methods; most operators believe that a strip of gauze should be carried down to the site of operation for subsequent drainage. In case the patient is in serious condition it may be wiser to make a fecal fistula by drawing the ruptured gut up into the wound. If adhesions have begun to form, it is questionable whether these should be further broken up, after finding the perforation, since then not only the limiting wall, but also the abraded surface left offer a most favorable atrium for the rapid entrance of germs and toxins. It is probable that the wisest procedure is to close the ruptures found easily, and get the patient back to bed at once. It also follows that in such cases the abdominal cavity should not be irrigated. Where adhesions have not formed on account of the early operation, more careful search can be made. If the peritonitis is general without adhesions, the intestines should be searched quickly and carefully. Whether the abdominal cavity should be flushed out or only drained is still undecided. Andrews inserts tubes down to the various peritoneal pockets and has a constant stream of normal salt solution running in and flushing out the abdomen while he is operating. Other surgeons believe that the less the cavity is disturbed the better, and insert gauze strips into the various pockets. It is not our purpose, however, to discuss here the various questions as to peritonitis. If an abscess has formed and the patient is in a serious condition, the wiser procedure is to drain the abscess and at a later date close the fecal fistula if it persists.

If a seriously contused area is found, the wall can be rolled in. If the mesentery is injured, careful examination should be made of the vascular anastomosis, and if there is any question as to the destruction of the blood-supply the bowel should be resected. This should be emphasized, since the mortality in these cases has been high. This will frequently be found necessary where the tear is near the gut, as has already been pointed out.

Search should be made for injury of other viscera.

DUODENAL ULCER.

Ulcers of the duodenum may be of the so-called "peptic" variety, since the digestive juices of the stomach may still be active there. Further down the intestine the admixture with the other fluids of the part neutralizes the action of the gastric juice.

Perforation is a frequent complication of ulcer of the duodenum and is apt to be the first manifestation of the disease, which often remains

latent, according to Cumston.[28] Collin found that perforation took place in 181 cases out of 262; in other words, in 69 per cent., but this may be larger than the actual percentage, since many cases of ulcer are only diagnosticated at the autopsy. In a large number of records the ratio of one female to five males is maintained, the disease being most frequent between the ages of thirty and forty. The usual seat of the disease is the first portion of the duodenum, near the pylorus. Loss of tissue in perforation is usually discovered on the anterior aspect of the organ, because the lesion occupies the most movable portion of the duodenum, which is more completely covered by peritoneum. Alloncle found that perforation occurred on the anterior wall in 60 per cent. of all cases examined, and Collin came to practically the same conclusion, namely, in 59.6 per cent. of cases. Therefore, when dealing with a case of perforating peritonitis of a probable gastroduodenal origin, the anterior aspect of the duodenum, and especially its first portion, should be the first portion explored. There is no definite symptomatology.

When perforation occurs, the most noteworthy point is the suddenness of onset. The diagnosis is difficult, and there is but one treatment, laparotomy. It is always well to let the initial shock pass by and allow the patient to gain some strength before opening the abdomen. From three to four hours is usually sufficient for this to take place. In order to expose the perforated duodenum the best incision would naturally be one made parallel to the linea alba, about 5 cm. or a little more to the right, commencing at the eighth costal cartilage and made as long as requisite for the case. When the perforation is easily accessible, one has at his disposal, as in gastric ulcer, three technical possibilities: namely, suture of the perforation with or without resection of the ulcer; intestinal anastomosis, with or without suture of the bowel or resection; and, thirdly, enterostomy, or fixation of the borders of the ulcer to the abdominal wound. The first procedure should be employed when possible, while the other two are to be reserved for those cases where the changes in the tissues are so extensive that it is not possible to suture. Enterostomy is resorted to in those cases where the patient's condition obliges one to act with speed. If the perforation is difficult to reach, so that no sutures can be used, all that can be done is to wall off the parts and resort to large drainage-tubes and gauze packing. If the general peritoneal cavity has become involved, it should be drained.

There has been an increasing number of individual cases published since 1901, when Moynihan collected 51 cases operated upon. M. S. Smith[29] records 14 cases of acute perforated ulcer of the duodenum, 12 males and 2 females, the average age being forty years. Three were not operated upon. One was in such collapse that an operation was considered out of the question. The patient died within thirteen hours of the perforation. One was brought into the hospital in a moribund condition five days after perforation and died while preparations were being made for operation. In one case the condition was found post-mortem. Eleven were operated upon, with five recoveries and six deaths. Of those that died, one went into collapse under the anesthetic, so that the

closure of the ulcer had to be abandoned, and the patient died within a few minutes. In another case the perforation was not found at the operation.

Perforated duodenal ulcers may be best divided into three classes:

1. Acute perforation of the peritoneum-covered surface of the duodenum with profuse escape of intestinal contents rapidly flooding the whole peritoneal cavity. Cases of this class result in general septic peritonitis.

2. Acute perforation of the peritoneum-covered surface of the duodenum with moderate escape of intestinal contents filling up a part only of the peritoneal cavity—a part of large extent, but with certain definite and constant boundaries. Those of this class result in one of two ways: A localized but extensive abscess may form, or, secondly and more frequently, the fluid, after remaining for a time within its original bounds, is increased in amount by further escape and invades the peritoneal cavity far and wide, giving rise to general septic peritonitis.

3. Chronic perforation of the non-peritoneum-covered surface of the duodenum or of a part of its peritoneum-covered surface which has become adherent to surrounding structures. Cases coming under this heading result in a localized abscess, chronic peritonitis with adhesions, or rarely a duodenal fistula.

No sharp line can be drawn between the two latter varieties; the second is more common than the first. There is in the majority of cases an interval during which the extravasated contents, although no adhesions have formed, are limited to a particular region of the abdominal cavity. The evidence that may be adduced in favor of this statement may be studied under three headings: (1) Experimental; (2) results of operation; and (3) situation of abscesses.

Experimental evidence: With a view to investigate the course taken by fluid from a perforated duodenal ulcer Smith has carried out a series of experiments on the dead body. The pathologic condition was reproduced by passing an esophageal tube into the stomach from the mouth and attaching to it a glass tube which passed through the pylorus and was brought out of a hole in the duodenum in the usual site of perforation. The end of this tube was then tied in flush with the duodenal surface. It was possible to do this without disturbing the anatomic condition of the part. The incision in the abdominal wall made for the purpose of these manipulations was then closed. By means of a funnel attached to the esophageal tube fluid was poured down the tube and made its exit into the peritoneal cavity at the site of the artificially perforated duodenal ulcer. The fluid used was water with zinc oxid suspended in it by means of tragacanth emulsion. In every instance the fluid ran downward in the direction of the right kidney pouch and collected in a space bounded: in front, by the under surface of the right lobe of the liver and the hepatic flexure of the colon; behind, by the anterior peritoneum-covered surface of the right kidney and the posterior abdominal wall; and inside, by the duodenum itself and the foramen of Winslow. In an upward direction this pouch spread behind the liver, between that viscus and the diaphragm,

but here its progress was blocked by the inferior layer of the coronary ligament. Away from the middle line, however, it stretched uninterruptedly to the right of the lateral hepatic ligament to the upper surface of the liver as far as the reflection of the falciform ligament. Downward this space was limited in part by the reflection of peritoneum from the hepatic flexure of the colon on the face of the kidney and the second part of the duodenum. When fluid had filled up the right kidney pouch, it always followed certain definite paths. It did not pass through the foramen of Winslow into the lesser sac of peritoneum. It had little tendency to find its way beneath the diaphragm. It always descended along the outer side of the ascending colon as far as the brim of the pelvis. The level of the fluid rose until it reached the level of the pelvic brim. It then overflowed into the pelvis. It must be remembered that this collecting body of fluid is dammed up on the inner side by the ascending colon. If this has no mesentery, the colon may be so bound down into the loin that the level of the fluid reaches above the summit of the ascending colon "dam" before it rises above the level of the brim of the pelvis. In this case the fluid will first leave the right kidney pouch by crossing the ascending colon, usually a few inches below the hepatic flexure. Even if the fluid takes this course it still tends to flow to the region of the appendix, guided thither by the obliquity of the mesentery downward and to the right and by the slope of the abdominal wall away from the middle line. It does not directly invade the left half of the abdomen, but crosses the termination of the ileum and reaches the right side of the pelvis practically at the same spot as before.

There still remains the point as to what guides the fluid toward the right iliac fossa in the first instance. This experimental evidence is confirmed by the results of operation, which have shown not infrequently the extravasated fluid limited to the right renal pouch and extending down as far as the outer side of the cecum, without overflowing into the pelvis. Conditions found at operation on Case 14 are of interest. There was a collection of fluid and pus bounded on the outer side by the cecum, limited internally by coils of small intestine, and in front by the great omentum, which was loosely attached to the cecum and intestine by recent lymph. The space thus bounded was continuous over the termination of the ileum with the cavity of the pelvis, which also contained fluid and pus. In an upward direction there was a well-defined track of suppuration crossing the ascending colon just below the hepatic flexure and leading to an accumulation of several ounces in the right kidney pouch. The anterior surface of the first part of the duodenum was found perforated and there were no surrounding adhesions whatever, but the course of the escaped fluid had evidently followed exactly the course described under "experimental evidence."

In all cases recorded in which abscesses had formed as a result of acute perforated duodenal ulcer, the walls of the abscess cavity have been formed by the structures mentioned above as limiting the right renal pouch. This collecting of the fluid in the right kidney pouch indicates what Smith thinks to be an important point in the treatment.

Mayo[30] has published a series of fifty cases of duodenal ulcer. He

states that in his opinion the causation and continuation of duodenal ulcers depend upon the irritating secretions of the stomach, and that these must be diverted by gastro-enterostomy.

Of his group of perforation cases, six were instances of acute perforation. In all but one the perforation was a complication of chronic ulcer with a history of four to twenty-one years' standing. One patient died from inanition from prolonged leakage, although a gastro-enterostomy was done at the same time. One patient died from pneumonia on the tenth day. The other cases recovered.

Hemorrhage occurred in one case with death. At the operation the ulcer was easily recognized, and was excised, the pylorus at the same time being enlarged. Death occurred from pneumonia on the fifth day.

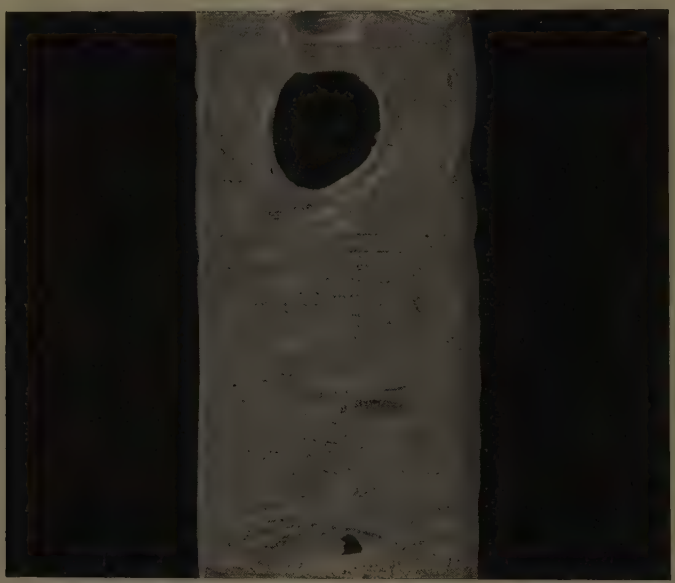

FIG. 379.—TWO INTESTINAL PERFORATIONS IN TYPHOID FEVER (Museum of the Pennsylvania Hospital).

A third small perforation existed just above the large one. Resection of the bowel would have been the only possible mode of treating the large perforation, as lateral closure would have produced great stenosis. Observe the numerous areas of thinning of the wall of the bowel from ulceration (Keen).

Gastric complications occurred in twenty-eight cases. One death occurred from the prolapse of a long transverse colon over the loop of jejunum used for gastro-enterostomy.

Complications with disease of the gall-bladder and liver were noted eleven times. No deaths occurred from operation.

The remaining thirteen cases, in which there were no symptoms calling for operation on the stomach or the gall-bladder, showed no deaths.

Perforation in Typhoid Fever.—The frequency with which perforation occurs in typhoid fever is illustrated by the recent statistics collected by J. A. Scott.[31] He estimates that about one-third

of the deaths in this disease occur from perforation. In 3006 cases the general mortality was 8.05 per cent., while the mortality from perforation among these cases was 2.58 per cent. Of sixty cases operated upon, thirteen recovered.

The diagnosis rests upon the occurrence of sudden pain followed by tenderness and rigidity. The presence or absence of liver dullness and the leukocyte count are considered of no value by Scott, while a certain proportion of the cases will not exhibit pain or rigidity. To be excluded are pneumonia and pleurisy, urinary retention, thrombosis of the iliac or femoral vein, and peritonitis.

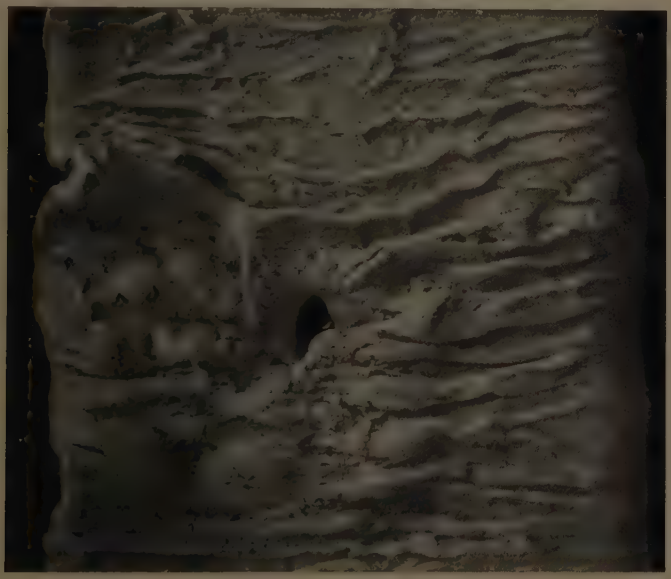

FIG. 380.—INTESTINAL PERFORATION IN TYPHOID FEVER (Museum of the Pennsylvania Hospital). Observe the thinned wall around the perforation (Keen).

The most common time for perforation to occur is between the fourteenth and twenty-first days. It is most common in the cases of moderate or severe type. Almost all the perforations occur within 12 inches of the ileocecal valve, although the appendix and colon are not infrequently the site of the lesion.

The diagnosis having been made, operation must be performed immediately. Closure of the perforation and drainage constitute the surgical requirements.

Perforating Typhoid Ulcer.—Greaves[32] reports three cases of typhoid ulcer with perforation which he operated on, two of which recovered, one dying of bronchopneumonia. He objects to glass drains in the lower part of the abdomen: (1) The "drain" is acting under the mechanical disadvantage of the patient lying upon his back, forcing all the fluid to pass uphill. (2) Whereas perfect rest is greatly to be desired

in any case of general peritonitis, but especially in typhoid fever, the presence of the drainage-tube adds to the difficulties of nursing, and must be constantly emptied by a suction syringe. (3) The drainage-tube provides an open path for the intrusion of germs from without. (4) The drainage-tube, if flexible, is easily occluded, and so rendered useless; if rigid, it may by its pressure injure the intestine or bladder. A fecal fistula has resulted from such pressure. (5) On withdrawing the tube, some portion of the bowel, such as the appendix, Meckel's diverticulum, and appendix epiploica or part of the great omentum, may have entered the tube and be withdrawn also. Drainage should be reserved for the most septic cases, and then applied to the dependent parts, such as the lumbar regions, rather than to the abdominal incision. The abdominal wound should be closed in layers and the suture should be interrupted. To guard against infection of the subcutaneous fatty tissue it was suggested that a small drain should be inserted into the wound at the lower end of the incision after the peritoneum is completely closed, removing one of the interrupted sutures when necessary.

One of the earliest papers on intestinal perforation in typhoid was published in 1891.[33] I was then able to report three cases in which I had performed the operation, one of the cases recovering. This seems to have been the first case of recovery where there was no doubt of the diagnosis of typhoid fever.

Scott places the proportion of operative recoveries at 21.6 per cent. in his series of eighty-four cases.

Charles F. Mitchell[34] reported eight cases of typhoid fever with perforations upon which he had operated. All the cases were males, their ages being from eighteen to twenty-eight years. Upon exploring the abdomen one case failed to show a perforation. This patient recovered. Four of the remaining seven cases died, and three recovered, a mortality of 57.1 per cent. The first symptom of perforation appeared in three cases on the fifteenth day of the disease, in the other five cases on the tenth, twelfth, twenty-first, twenty-sixth, and thirty-sixth days respectively.

The time between perforation and operation, reckoning from the first onset of pain, had been in the cases that recovered four and a half, eight, and ten hours, while in the four that died it was three, eight, twelve, and fifteen hours.

The leukocytes were counted in all but one case and all showed a leukocytosis except in one of the three which recovered, which showed a count immediately before the operation of 5900. None of the cases had more than one perforation. Four of the perforations were of pinhead size, one the size of a lead-pencil, and one that of a slate-pencil. All the perforations occurred in the last 18 inches of the ileum. The operations were done under ether anesthesia, the incisions being made through the outer border of the right rectus or through the right semilunar line. The abdominal cavity was flushed with salt solution in two of the cases, both of which died. Gauze drainage was used in every case.

ULCER OF THE JEJUNUM.

After gastro-enterostomy ulcers of the jejunum occur most frequently in men of middle or advanced age.[35] As to their clinical course, two groups are to be distinguished. In one case the course is devoid of symptoms until perforation takes place into the free abdominal cavity. In the second case a chronic course is pursued, characterized by severe distress or pain. Gradual penetration of the ulcer, adhesions, and involvement of neighboring organs are then likely to occur, leading to the production of considerable inflammatory tumefaction. The latter cases give the clinical picture of penetrating gastric ulcers, and are scarcely to be distinguished from them. There is a great tendency for them to recur, so that, after operations, the result, as far as permanence is concerned, is not good, though the few experiences with internal therapy in the absence of perforation are favorable. Tiegel ascribes the origin of the ulcer in the first place to the peptic action of the gastric juice supported by circulatory inactivity (arteriosclerosis), lesions of the mucous membrane, and perhaps by individual disposition. As yet it is impossible to say that any special operative method or technic of gastro-enterostomy is responsible for the ulceration. Tiegel recommends that internal treatment be directed to the prophylaxis of this condition and suggests the use of alkalis and a strict diet.

SARCOMA OF THE SMALL INTESTINE.

E. Libman, of New York,[36] has had an extraordinary experience with the rare sarcomata of the small intestine, and has made an extensive study of the literature of the subject.

No case of this kind was observed in the Berlin Pathological Institute from 1859 to 1875. Smoler studied 13 cases occurring at Prague within fifteen years among 13,036 autopsies. Twelve cases, according to Nothnagel, occurred in Vienna between 1882 and 1893.

The small intestine is most frequently the seat of these lymphosarcomata. In the large intestine they are much rarer, except in the rectum, where they occur as frequently as in the small intestine. Krueger gives the following statistics of 37 cases: The small intestine, 16; ileum and cecum, 1; small intestine and colon, 1; rectum, 16.

Baltzer states that 57.8 per cent. of the cases occur in the fourth decennium.

The disease seems to be quite as frequent in males as in females.

As to the more intimate causes of the malady, nothing is known.

Libman found among 42 cases, 15 involving the duodenum, 18 the jejunum and ileum, 14 the ileum, and 3 the entire intestinal tract.

All microscopic varieties of sarcoma are observed in the intestine. Usually the neoplasm involves only the mucosa and the muscularis, the serosa being almost or quite free. In quite isolated cases the neoplasm took its origin in the serosa, and extended from there to the inner layers. The lymphosarcomata, which form the largest group, begin commonly

in the submucous lymph-glands and grow along the long axis of the bowel. The muscularis is early involved and paralyzed, permitting the feces and gas to dilate the bowel. This intestinal dilatation is an especial, although not constant attendant phenomenon of lymphosarcoma of the intestine.

The tumor may compress the vena cava, the biliary passages, the ductus pancreaticus, or the ureters.

Ulceration is very frequent, and may lead to perforation either through an intestinal loop or into the abdominal cavity.

Metastases may take place in various parts of the body.

Symptoms.—The symptoms include an early involvement of nutrition. Baltzer states that the first symptoms are transitory abdominal pain, anorexia, nausea and vomiting. The abdomen is soon distended, the patients become thin and pale, and usually a tumor is demonstrable, though this may be long imperceptible.

Of the special symptoms the pain, usually in the epigastric region, and distention of the abdomen are very prominent. The latter often occurs suddenly, and the phenomena of the disease may have their beginning in this symptom. The distention may be due to the involvement of the peritoneum, pressure upon the vessels, intestinal perforation, tympanites, or the mere size of the tumor. An effusion may be present, clear, milky, purulent, or hemorrhagic.

The tumor usually feels like an irregularly shaped mass, while in reality the neoplasm is only small and the nodular character of the mass is brought about by metastases in the peritoneum and lymphatic glands. One often feels small nodules that seem to be lymphatic glands, but on post-mortem examination are found to be infiltrated appendices epiploicæ. The tumor may be superficial or deep. As a rule, it is not tender. It is movable with respiration, and usually can be pushed about in the abdomen. A dull note is for the most part obtained upon percussion. Though quite soft and very hard tumors have been described, as a rule the consistency is moderately hard. Indistinct fluctuation is sometimes felt; the tumor may take part in the peristaltic movement of the intestines and crepitation is sometimes felt over the tumor.

The position of the tumors is very variable. They have a great tendency to grow backward, and they may occur primarily in the lower part of the abdomen, so that rectal examination may lead to the recognition of a tumor which cannot be palpated from above.

Naturally a number of compression phenomena may be observed, such as ascites, swelling of the legs and scrotum, dilatation of the veins of the chest wall, icterus and acholic stools, difficulties with urination and diminution of the quantity of urine.

Gastric symptoms, such as anorexia and vomiting, are not uncommon. At the epigastrium a feeling of pain may be present.

Intestinal symptoms are associated with depression and diarrhea, the dilatation of the bowel already mentioned being borne in mind.

A consideration of the metastatic relations of these tumors, together with the pressure relations, will suggest the phenomena to be observed upon the side of the liver, the lungs, the urinary organs, and the rectum.

No characteristic blood findings are noted.

The course of the disease has suggested to Lidman the following classification: (1) latent cases in which the tumor is first discovered at autopsy; (2) cases in which either general symptoms, the distended abdomen, or the tumor excite attention; (3) cases in which the first symptoms are brought about by intestinal occlusion or perforation; (4) those in which a similarity to tuberculosis of the peritoneum is demonstrable, and in which no tumor is to be felt; (5) cases in which icterus is the first symptom; (6) in one case there was great similarity to ovarian cyst; (7) finally, cases in which a pronounced resemblance to appendicitis is present, an observation first made by Lidman.

Since there is no pathognomonic symptom, it is necessary to take into consideration the symptom-complex already detailed, and, as far as possible, to depend upon differential diagnostic points in addition.

Carcinoma of the intestines and the peritoneum will always present difficulties of diagnosis, the chief distinctive feature being that pertaining to age. Below fifteen years of age the probabilities are in favor of sarcoma. After forty years of age sarcoma is less probable, though not to be excluded. Against carcinoma are absence of glandular infiltration, absence of pain, and the size of the growth.

Tuberculous peritonitis and tuberculosis of the mesenteric glands are to be considered. A case of Nothnagel's presented a difficulty of this kind, the autopsy showing that a lymphosarcomatous neoplasm had arisen upon the basis of cicatrized tuberculous ulcers. The presence of a very large tumor or of several tumors speaks more for sarcoma. In tuberculosis ascites is usually an early symptom.

Sarcoma of the kidneys, ovarian tumor and cysts, neoplasms of the bladder and prostate, retroperitoneal sarcoma, and appendicitis with or without peritonitis may require consideration.

The duration, according to Baltzar, is from one-half month to one year and nine months, most of the cases dying within nine months. The prognosis is inevitably death. Even surgical intervention apparently yields but poor results, so far as the final result is concerned. Libman warns against operation in cases of lymphosarcoma with extensive metastases, even for the purpose of exploration, since the fatal result may be hastened in that way. Arsenic has been recommended by some writers.

THE COLON.

Dilatation of the Colon.—Congenital dilatation of the colon is also known as Hirschsprung's disease, in recognition of his having first studied it. The explanations of the dilatation are variable. Nothnagel and Concetti speak of a congenital weakness or partial defect of the muscularis in the lower section of the bowel with secondary hypertrophy of the upper part. Mya considers the disease a simple congenital hypertrophy and dilatation (megalocolon).

The disease is usually observed in young infants brought to the physician on account of obstipation. Days and weeks pass without move-

ments of the bowels and quantities of hardened feces are found. The children, usually boys, are often in a condition of extreme debility; the abdomen is usually distended; as a rule, the enlarged loops of intestine can be demonstrated by palpation and percussion, while exaggerated peristalsis can frequently be seen. The diaphragm is elevated by pressure. Escherich noticed undue mobility of liver, spleen, and kidneys. The finger introduced into the bowel demonstrates the ampulla to be empty. If a tube is introduced into the bowel, the gas is allowed to escape, when, as a rule, it may be found that a large dilated part of the intestine can be palpated through the abdominal wall, usually in the right hypochondrium. The sphincter is usually in a state of contraction.

The **treatment** is medical except in so far as the relief of malformations is concerned. Resection of the large intestine has been proposed by Fenwick. The establishment of an artificial anus has been suggested. It is not probable that either of these severe operations will be required except in the rarest instances.

Carcinoma of the Colon.—Carcinomata, infiltrating, medullary, and scirrhus, occur in the colon, for the most part after middle age, though occasionally seen in the fourth decade and rarely below the age of thirty. While the sigmoid is the most frequent seat of the disease, it occurs at the two flexures in the descending colon, and finally in its transverse and ascending part. The scirrhus type is naturally of slow growth and frequently leads to early stenosis, making the disease recognizable at a stage in which operation can be rather satisfactorily performed. Above the point of constriction hypertrophy of the intestinal wall occurs if stenosis has taken place to such a degree as to require additional force to drive the fecal matter through the narrow opening. When the hypertrophy becomes insufficient, dilatation results, and ulceration may occur in the injured bowel.

The more massive carcinomata may give rise to the same morbid anatomic changes, but as their structure is softer, and as they have a great vascularity, ulceration and bleeding can occur in the part affected by the tumor as well as above.

The prognosis as to length of life in carcinoma of the colon is better than that attending cancerous disease in any other part of the tube.

Symptoms.—These growths give rise to the symptoms which are dependent upon the progress of the neoplasm in the tissues of the affected organ, to those which are dependent upon obstruction of the lumen of the bowel, to those that may be referred to metastases in glands or distant organs, and to those which are brought about by adhesion and ingrowth into neighboring structures.

As a rule, it is long before the mere growth of a carcinoma in the wall of the colon causes pain enough to drive the patient to the physician. Yet these carcinomata can give rise to some disturbance as the mere result of invasion of the bowel wall.

As a rule, symptoms are first observed when ulceration with diarrhea, persistent fetid discharge, and hemorrhage are observed. These symptoms often excite the patient's fear of cancer. The ulcerative symptoms

may be serious and the hemorrhages may be severe, but this is not usually the case unless the canalization of the organ is affected.

When constriction has begun to occur, we may have the classic symptoms of chronic intestinal stenosis, or if the narrow opening left by the advancing disease is suddenly occluded by some fecal mass or some foreign body, such as a fruit-stone, we may have acute intestinal obstruction.

Treatment.—The importance of obtaining an operative field comparatively or altogether free from the highly infectious contents of the large intestine has long been recognized. A preliminary colostomy has been frequently performed with great advantage.

Schloffer[37] proposes the resection of carcinomata of the large intestines in three tempos. At the first sitting a colostomy is performed, causing the fecal matter to be discharged upon the skin at a point well above the site of the carcinoma. At the second operation the excision itself is practised and the field of operation thoroughly drained. At the third sitting the fecal fistula is done away with and the continuity of the bowel restored.

This method of operating, though very trying to the patient, yields excellent results, the mortality having been reduced from 43 per cent. (Czerny, v. Mikulicz) to zero in seven cases operated on in the Wölffler clinic and 20 per cent. in five cases operated upon recently in the Czerny clinic.

Duval[38] describes three varieties of carcinoma of the sigmoid flexure according to their seat: (1) ileopelvic; (2) sigmoid; (3) rectosigmoid; according as the tumor belongs to the uppermost, the middle, or the lower section of the sigmoid. To these may be added as a fourth variety the diffuse carcinomata located above the entire flexure.

Anatomy of the Splenic Flexure.—The situation of the splenic flexure is such that it lies behind the body of the stomach, in front of the left kidney, and reaches the basal surface of the spleen.

The splenic flexure may be in a certain sense lacking; that is, the transverse colon may run from its point of fixation on the right and above more or less directly toward the left and downward. That portion of the intestine corresponding to the splenic flexure then comes to lie below the border of the ribs, even in the region of the umbilicus. Curschmann was the first to call attention to this unusual condition of things.

A false splenic flexure may be produced by a part of the left half of the transverse colon bending downward in front of the actual point of flexion of the splenic part of the colon. It is characterized by the absence of the suspensory ligament.

According to Madelung,[39] the lymphatic vessels and glands of the splenic flexure are so related that the conditions for the spread of carcinoma are not favorable, a great difference in this respect being observed between the splenic flexure and the cecal and colonic parts of the large intestine.

Inflammation and Wounds of the Splenic Flexure.—The splenic flexure is subject to inflammation, the disease beginning both externally and internally to the tube.

Inflammation outside the splenic flexure may lead to abscess formation about the tube.

Scar contraction may take place by the gradual shortening of extra-intestinal inflammatory masses and by the shrinking of new-formed connective tissue due to ulceration in the bowel.

Nothnagel has called attention to a case in which stricture occurred in the region of the splenic flexure after dysentery. When Billroth operated on this case, he found the stricture, and in addition a carcinoma which had developed in the scar.

Typhoid fever, intestinal tuberculosis, and intestinal syphilis may give rise to such strictures.

Only a few penetrating injuries of this part of the bowel have been found by Madelung in the literature, where the spleen was injured in seventy-one cases of gunshot wounds and seventeen of punctured wounds, the splenic flexure was simultaneously injured only once. A case is cited in which the liver was simultaneously injured, and another where the left kidney was perforated by a gunshot wound at the same time.

Neoplasms of the Splenic Flexure.—Non-malignant neoplasms of the splenic flexure have rarely been noted (Madelung). Even mucous polypi are rare in this part of the bowel, though, of course, when general polyposis of the colon has occurred the splenic flexure has taken part in the process.

In his search of the literature Madelung was not able to find a case of sarcoma in this part of the intestine.

The carcinomata are, however, not so rare, ninety-three cases having been collected by him. In addition to this number he observed seven cases himself, making a total of one hundred.

All the cases were of the cylindric-celled variety, almost all being scirrhus. In only one case was the cancer described as extremely soft, vascular, and hemorrhagic. Five cases showed colloid degeneration.

Very frequently the carcinomata of the splenic flexure led to circular constriction of the bowel. Above the stricture the usual lesions due to accumulation of feces, ulceration, and catarrh are observed.

Adhesions to neighboring parts, such as the stomach, spleen, left kidney, large omentum, parietal peritoneum, small intestine, lower end of the duodenum, or the tail of the pancreas, may occur, though, as Madelung remarks, it is still more striking that such adhesions are sometimes absent.

Rupture of the carcinomatous colon into the neighboring hollow organs may occur. The stomach and small intestine are mentioned in this connection.

Circumscribed intraperitoneal abscesses were occasionally observed about such carcinomata. Diffuse purulent peritonitis occurred in only a few cases. Metastases occurred only rarely, even in the neighboring lymphatic glands.

The clinical course of these cancers is the more difficult to study because of the impossibility of recognizing the disease in its incipiency.

The cause of the carcinomatous change is, as usual, difficult to fix. Antecedent ulceration, cholera and dysentery, and long-standing obstipation are occasionally mentioned. In rare cases the course of the disease is run without much disturbance of the bowel function, the patients losing weight, becoming anemic and cachectic. On the other hand, patients in good general health may be suddenly seized with symptoms of intestinal occlusion, death may ensue, and the post-mortem show an advanced carcinoma as the cause of the obstruction.

As a rule, it is intestinal symptoms that first call attention to the disease. Abdominal discomfort may gradually call attention to the affected part, though often sudden pain is the first sign. This pain is not unusually provoked by violent physical activity. Loss of appetite, diarrhea, and occasional attacks of colic are common symptoms.

The demonstration of a carcinoma of the splenic flexure by palpation through the abdominal walls is, as a rule, impossible, even with the aid of narcosis, on account of the position and fixation of the part. The exceptions apply almost exclusively to tumors so large as to be no longer operable. It should, therefore, be the aim of the practitioner to reach a basis for action without waiting for the discovery of a palpable mass.

Some have endeavored to base the diagnosis upon a study of Nothnagel's Darmsteiffung (intestinal hardening or stiffening) symptom, but Madelung has never been able to find this symptom or anything even approximately like it.

Distention of the colon with air has also been of slight value.

The discharge of blood from the bowel is of less diagnostic value because it rarely occurs without extensive ulceration.

It is a curious fact that the recognition of carcinoma of the splenic flexure, even after laparotomy has been made, may be very difficult when the tumor is comparatively small, on account of the fixation of the part to the posterior abdominal wall. Careful palpation must be depended upon to recognize the tumor, which may be small and retracted toward the posterior wall of the abdomen.

The termination of these carcinomata is often by obstruction of the bowel, but may be by perforation into neighboring structures or cavities, or by exhaustion.

Treatment.—The treatment of these carcinomata must, for the most part, be surgical.

Of the one hundred cases studied by Madelung, forty-nine were operated upon in a palliative way. Enterostomy was performed in twenty-six cases, in twenty-four of which intestinal occlusion had occurred. It was seldom that life was very much prolonged.

Entero-anastomosis was done twelve times, but without very much benefit to the patient. Of the six patients who survived the operation, one lived six months and one a year, while two were living at the expiration of two and three months after operation.

Resection was carried out thirty-four times with twenty operative recoveries. One patient died seven months after operation, four others lived

and were well after respectively one and one-half months, two and one-half months, five months, and nine months, and three two years after operation. In six cases permanent cure was apparently obtained, the patients having remained well for more than three years.

Madelung draws the important conclusion from the study of these cases that it is an established fact that carcinoma of the splenic flexure is curable by intestinal resection, even in advanced stages of the disease. We are encouraged to think that future results will be even better than those already attained by the fact already mentioned that in the post-mortem examinations recorded metastases in the liver were rare, and in some other distant organs were not observed at all, while regional extension to lymphatic vessels and glands was but slight and pronouncedly tardy.

The method of operating in three tempos is considered by Madelung the most applicable to this disease.

Appendicostomy.—Gibson suggested that in amebic dysentery when the common internal treatment fails, and when the patient is not too much reduced in strength, irrigation of the large intestine may be undertaken from a fistula of the cecum. Weir suggested that it might be done through an appendicostomy opening. Curl[40] prefers the cecal fistula on account of the difficulty of closing the appendicostomy fistula when its usefulness is over. He recommends an opening so small that only a large soft catheter can find entrance. In eleven cases treated in this manner eight showed a favorable result, under irrigations with quinin solution. (See p. 720.)

Inflammation of the Mesocolon.—One of the causes of volvulus recognized by many writers is inflammation of the mesentery or of the mesocolon. Emil Ries has discussed mesosigmoiditis in its relation to recurrent volvulus of the sigmoid very clearly. It is well known that shortening of the mesosigmoid increases the danger of volvulus resulting from gangrene. White strips of scar tissue have been observed in the mesosigmoid, and the retraction which follows upon the formation of this scar tissue is an important factor in the complication of the course of volvulus; not only is the mesosigmoid shorter, but also its blood-vessels are interfered with to such a degree that a very slight twist of the intestines may lead to rapid gangrene and perforation. In some cases the symptoms of volvulus of the sigmoid have been presented where no real twists of the bowel have occurred, but only a pronounced mesosigmoiditis was present. The shrinking of the mesosigmoid shut off the fecal current as well as the blood circulation.

Graser met with diverticula of the sigmoid which seemed to be the seat of the infection bringing about mesosigmoiditis. Ries considers that the ulceration of the diverticula constitutes the most important positive factor in mesosigmoiditis.

Charles M. Matter[42] has presented a most interesting case of localized inflammation of the sigmoid.

He states that the most prominent predisposing factor in sigmoiditis is constipation. The long-continued presence of hardened fecal matter

in the large bowel often gives rise to ulceration and deep-seated infection. Matter's case is as follows:

"An old lady seventy-eight years of age had been suffering with severe abdominal pain for four or five days previous to the day that I first saw her. The onset was acute, with diffuse colicky and burning pains in the abdomen, which, at the end of about two days, had localized themselves in the lower left quadrant. The pains at times would assume an expulsive character, associated with tenesmus. She had vomited once about two days previous to the time I first saw her, but not since. She was troubled greatly with expulsion of gas from the stomach and bowel. The bowels had moved once by enema.

"She had been constipated for some years, and during the last six months had occasional attacks of diarrhea, but no passage of blood or pus at any time.

"Present status. Small, anemic woman. Head negative. Moderate arteriosclerosis. Lungs practically normal.

"Abdomen: Somewhat distended; no peristaltic waves visible; no tenderness or rigidity, except in left lower quadrant, where a very tender, broad, elongated, smooth, resistant, sausage-shaped swelling was noticed, extending from about the level of the navel in the left mid-axillary line downward and inward to the middle of Poupart's ligament. On percussion, flat tympany, no gurgling, no peritoneal friction were noticed. Liver: Edge palpable; otherwise negative. Rectum and vagina: Negative.

"Careful examination revealed no palpable evidence of carcinoma at the time, nor has it since then. Because of the patient being at home, and not having very good or intelligent help, I could get the temperature only when I made my visits. Temperature: First day, 2 P. M., 100½° F.; second day, 6 P. M., 100° F.; third day, 4 P. M., 99° F.

"The tumor mass persisted for about a week, and then gradually began to get smaller, and simultaneously the pain and local tenderness diminished.

"The bowel movements, which could be obtained only by enema, consisted chiefly of mucus, with but little feces. No blood or pus at any time. There was practical recovery about ten days after the day I first saw her. Since then she has remained in good health."

Treatment.—When volvulus is recurrent and when the cause of the recurrence is partly the retraction of the mesosigmoid, some operative treatment should be applied in order to prevent a recurrence of the twist. Ries states that in carrying out Roux's suggestion of attaching the sigmoid to the abdominal wall, it is best to apply the mesosigmoid to the anterior wall rather than to the posterior to avoid injury to the ureter and iliac vessels. Riedel's method of dissecting out the scar tissue in the mesosigmoid was not favored by Ries because he thinks other scars would take the place of those removed. He would reserve the resection of the sigmoid for those cases of mesosigmoiditis where the shrinking is very pronounced or is complicated by irreparable changes in the substance of the bowel.

THE CECUM.

Actinomycosis of the Cecum.—Actinomycosis of the cecum has been studied in seven cases by Waring, who, contrary to the usual opinion, holds that the primary seat of the disease may be the colon itself as well as the appendix. The diagnosis rests upon the slowness of the course, the hardness of the tumefaction, the infiltration of the abdominal wall, and, finally, the formation of abscesses with discharge of pus containing the characteristic actinomyces.

It is usually impossible to remove by operation all the diseased tissue on account of the diffuse infiltration, and Waring recommends incision with emptying of the abscess, curettage, drainage, repeated irrigations with peroxid solutions, and the simultaneous administration of potassium

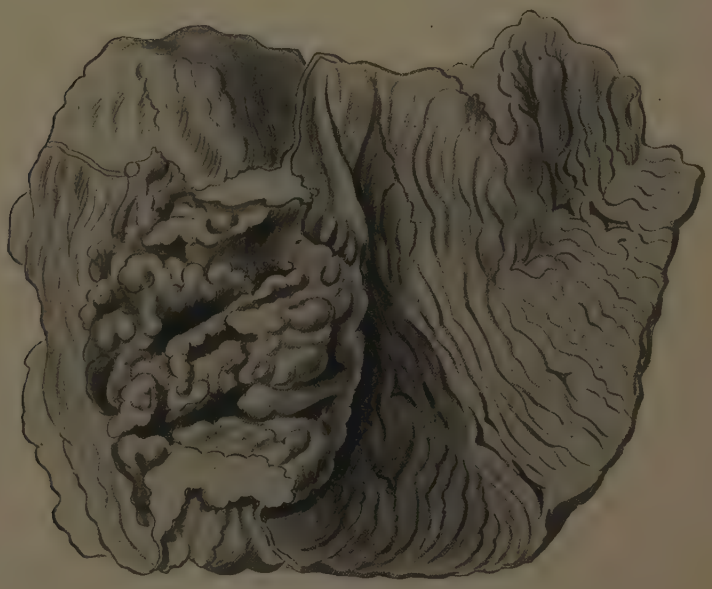

FIG. 381.—HYPERTROPHIC TUBERCULOSIS OF THE CECUM (Hartmann)

iodid. Four of Waring's cases recovered, three died. The deaths occurred in patients in whom in the course of the disease pyemic symptoms had supervened.

Tuberculosis of the Cecum.—The most comprehensive and valuable article we have on the subject of tuberculosis at the ileocecal valve is that of Hartmann, the substance of which was presented in December, 1906, before the Medical Society of London.[43]

Czerny, Durante, Billroth, and Pitha and Hartmann have given especial attention to this subject.

Fenwick and Dodwell note that 85 per cent. of cases of intestinal tuberculosis involve the ileocecal region, which is the sole seat of the disease in 6 to 10 per cent. of the cases.

The **etiology** of the disease contains many points corresponding to the etiology of tuberculosis in other parts of the body. It involves the two sexes with equal frequency. It attacks chiefly those of from twenty to forty years of age, although Guinon and Pater have recently published a case occurring in a child four years old. Other tuberculous lesions may be present in the same individual, but, as a rule, these lesions are but little advanced, and are sometimes wholly lacking.

It seems probable that the infection gains entry with the ingesta, and that the localization at the cecum may be due to the stagnation of the bowel contents at that point.

The **morbid anatomy** is described as including two forms, the ulcero-caseous and the hypertrophic form.

In the first of these the cecum may be alone involved, but this is the exception, the inflammation, as a rule, occupying at the same time the end of the ileum, which, like the cecum, is eroded by ulceration. The appendix is often destroyed. The ileo-cecal region is filled with a mass of adhesions with disseminated gas-containing spaces, and even tuberculous caverns with purulent contents sometimes communicating with the intestinal canal. Pyo-stercoral fistulas may form, discharging upon the skin, opening into the iliac fossa, but often at the umbilicus in the lumbar region, etc.

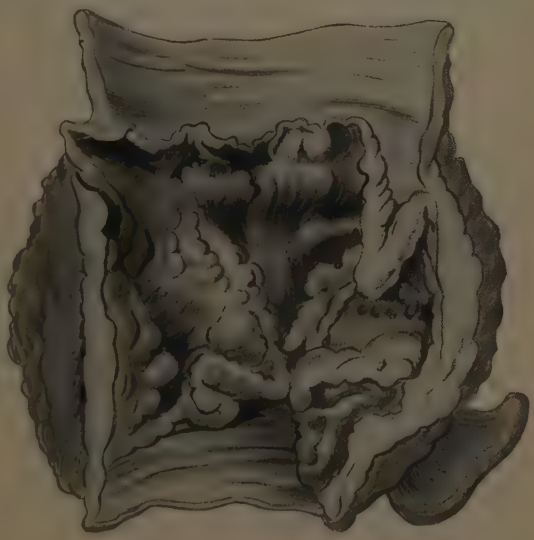

FIG. 382.—EPITHELIOMA OF CECUM (Hartmann).

The second or hypertrophic form was described in 1891 by Hartmann and Pilliet under the name of tuberculous typhlitis simulating neoplasm, and is the most important one for the surgeon to study. It is almost always limited to the cecum, only exceptionally involving the ileum, and then at a late period implicating the lower part of the organ. The ulceration may destroy the ileocecal valve and extend to the adjacent ileum, but the hypertrophic part remains limited to the cecum. The extension is by a descending process. Hartmann refers to a case in which the lesions left free the terminal part of the ileum and extended to the whole ascending colon, embracing even the hepatic flexure. Externally the cecum appears increased in volume, more or less movable from the iliac fossa, and enveloped in a sclero-adipose mass that may have an extent of 3 or 4 cm.

"This sclero-lipomatous mass, comparable to that which one observes

about a kidney subject to chronic pyelitis, is the manifestation of a chronic inflammatory process. It may extend to a point in front of the vertebral column, and contain in its interior lymphatic glands. The hypertrophy of lymphatic glands is constant in cecal tuberculosis, and more voluminous than that which one observes in cancerous tumors."

The retraction of this inflammatory tissue may raise the colon and cecum to a height. A variety of deformities of the tube take place corresponding to the contractions of the scar tissue. Stricture formation is likely also to occur, though, as a rule, the index-finger will pass the partial obstruction. Occasionally dilatation occurs above the diseased parts. Vegetations and even polypoid masses may be formed within the intestines. Microscopically, tubercles are to be seen in various stages of activity or degeneration. Ulcers and polypi show the characteristic minute anatomy.

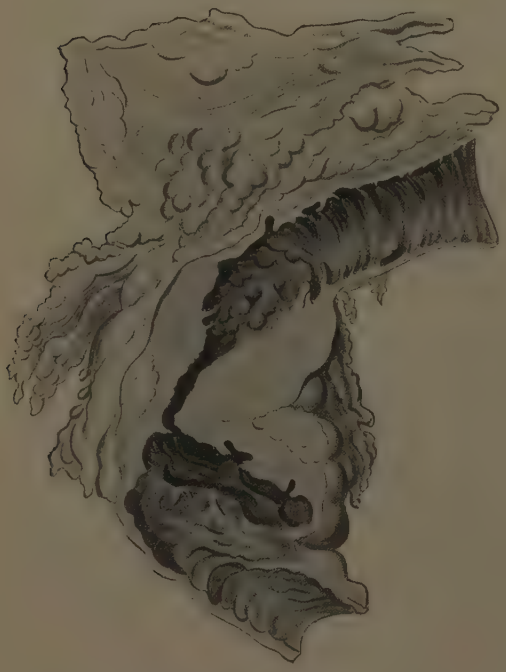

FIG. 383.—TUBERCULOSIS OF THE CECUM AND ASCENDING COLON (Hartmann).

The **symptoms** produced by the enteroperitoneal form are frequently similar to those produced by chronic appendicitis. The patient often suffers with diarrhea, the stools being abundant and bloody; later he complains of painful crises affecting the right iliac fossa. Such crises may be the first symptom of the disease, and may simulate appendicitis, especially as a tumefaction is to be felt in the appendiceal region. The inflammation extends over the internal iliac fossa toward the median line, becoming sometimes accessible to pelvic examination. A suppuration of slow progress then occurs, and external openings may form, with numerous fistulas. Naturally such abscesses may discharge into the bowel. It is only exceptionally that suppuration into the free peritoneal cavity brings about a lethal termination.

The hypertrophic form is by far the most frequent, and begins insidiously, with loss of appetite, impaired digestion, and vague disagreeable sensations in the right iliac fossa. For months the conditions remain the same, improving temporarily at times under treatment. Diarrhea and constipation are then likely to ensue, with colicky crises coming on

principally two or three hours after eating, with local meteorism, noises, and intestinal bruits. In other cases the signs of intestinal stenosis are less marked, or even completely lacking, the principal symptom remaining the slight painful crises. In the presence of these symptoms examination of the right iliac fossa reveals a mass which can be seen as well as felt. The tumefaction is hard, somewhat nodular, of elongated form, corresponding to the axis of the cecum, more or less mobile, this mobility being freer transversely than vertically. The tumor, limited by a rounded contour, is more difficult to circumscribe at the level of the upper part, which is a continuation of the colon. It is indolent or only slightly sensitive to pressure. Sometimes the tumor, in place of

FIG. 384.—TUBERCULOSIS OF THE CECUM WITH CONSIDERABLE SCLERO-ADIPOSE THICKENING (Hartmann).

occupying the normal situation, is placed as high as the level of the upper part of the iliac fossa. To percussion the cecal tumor does not give the normal resonance of the bowels. The evolution of tuberculosis at the ileocecal valve may be very slow, the tardiness of development being favored by freedom from involvement of the lungs and other organs. Little by little, however, the patient becomes weaker, the difficulties attending obstruction increase, and the general condition becomes worse. The enteroperitoneal form of the disease may succeed the simpler form already described. The disease in any case almost invariably progresses slowly to a fatal termination.

Though very difficult to fix, the duration of the malady is usually two and a half to three years. The difficulty in determining the length

of this period is dependent upon our inability to decide just when tuberculosis of the cecum itself begins.

The **diagnosis** involves a distinction between tuberculosis of the cecum and appendicitis. But the absence of the acute symptoms of appendicitis, of resolution of the indurated mass, the concomitant diarrhea, and the frequent coexistence of pulmonary tuberculosis may point the way to a correct conclusion. Naturally one would search for the tubercle bacillus in the discharges from the pyostercoral fistula.

Actinomycosis sometimes is to be suspected, especially if woody induration of the iliac fossa is present. When fistulas are present, they are recognized as pertaining to an actinomycotic process by the dis-

FIG. 385.—TUBERCULOSIS OF THE CECUM WITH POLYPOID PROJECTIONS (Hartmann).

charge of yellowish granules which are recognizable under the microscope as actinomyces.

Fistulas coming from inflammations of bone are to be excluded by following well-known rules.

It is the distinction between the hypertrophic form and malignant neoplasms of this region which gives rise to the greatest diagnostic difficulties. Attention to this fact was drawn by Hartmann and Pilliet in 1891, when they published a note upon a variety of tuberculous typhlitis simulating cancers in this region. In neoplasms the signs of stenosis, as a rule, run a more rapid course. The tumor has less the form of the cecum than is the case with tuberculosis, which, infiltrating the wall of the bowel, preserves its form to some extent. The reaction to tuberculin has not often been successfully used. The search for tubercle

bacilli in the feces Hartmann considers illusory, since they are found only in the ulcerated form. Fortunately, the treatment for both diseases is the same, and a distinction before operation is not absolutely essential.

The **treatment** of this disease is strictly surgical, extirpation being the ideal method of attack. The results have been fairly favorable. Of 229 cases operated upon, 46 died. Statistics, however, are here somewhat unsatisfactory. Before the year 1900 Hartmann finds 73 cases with 22 deaths, or 30 per cent. After 1900, 58 cases with 7 deaths. Hartmann himself has made 7 resections for tuberculosis, with 1 death. The 5 cases which he had operated upon since 1900 have all recovered. He thinks that the general mortality will continue to be lowered, and that in the future the percentage of recoveries will be much larger. This result is especially to be desired, since without operation the disease seems to be hopeless. The cure seems to be not only temporary, but permanent, as enough cases have been observed for several years to justify this conclusion.

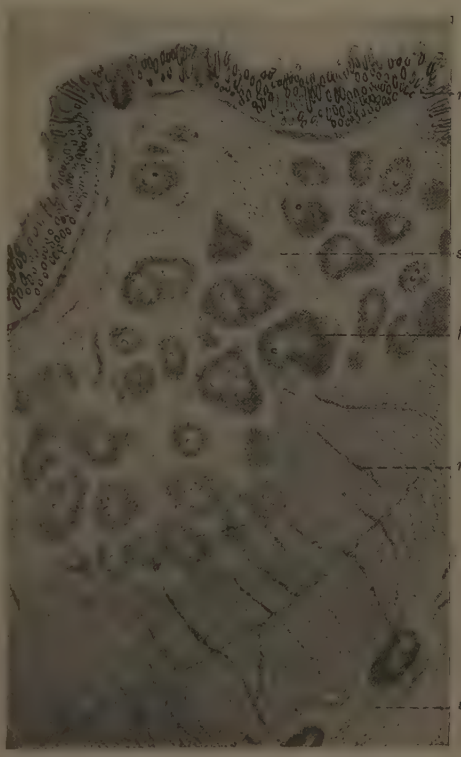

FIG. 386.—SECTION OF NON-ULCERATIVE CECAL TUBERCULOSIS (Hartmann).

m, Mucosa; *sm*, submucosa; *musc*, muscularis; *s*, serosa.

The ingenious mode of procedure which has been used by Hartmann is well illustrated by his figures, a new anatomic arrangement of ileum and cecum being provided for, closely simulating the original normal structures.

When ulceration or stenosis with its associated incomplete emptying of the bowel has long been in existence, the patient is likely to lose rather rapidly in weight and strength.

At this time the abdominal wall is likely to be raised by the distended intestines, the entire abdomen often being inflated. The circumscribed character of the meteorism has often been noticed. It is due, of course, to excessive accumulation of gas and fluid above, and more or less close to, the point of obstruction.

As a rule, the feces are voided only infrequently. The fecal masses are frequently hard and rounded. Pus and blood may be present.

A tumefaction may be palpated in about 40 per cent. of the cases (Treves), but on account of the relative non-malignancy of these growths, the presence of the tumor does not render the prognosis after operation so serious as is the case when a tumor is palpable at the pylorus.

A curious symptom has been especially studied by Hollender and Willy Meyer,[44] the occurrence of multiple capillary angiomata, manifold small pigmented spots, and flat warts in the skin of the abdominal wall. These changes do not occur exclusively in the presence of colonic cancer, but may be present in certain other forms of abdominal carcinoma, as, for example, carcinoma of the pancreas.

The diagnosis of these carcinomas cannot well be made without familiarity with tumors of the abdomen in general. It is necessary, first of all, to get rid of as much accumulated fecal matter above and below the growth as possible. This must be accomplished by lavage and laxatives, often to be used for several days before a final conclusion is reached. Direct inspection may reveal the carcinoma where Kelly's tubular specula can be used. These are manifestly not available when the disease lies above the sigmoid flexure.

Aside from the symptoms of intestinal stenosis, the depression of the general system, and the anamnesis, the most important points to consider are the presence of a tumefaction, its location and its mobility. Pagenstecher has called attention to the range of mobility of abdominal tumors and lays great stress upon the ease with which certain of the colonic tumors can be moved about in the abdomen. The inflammatory disturbances of the colon are excluded by diagnostic points to be referred to under their appropriate headings.

Nothnagel has called attention to a form of intestinal contraction which he names *Darmsteiffung*, or intestinal stiffening. Willy Meyer distinguishes between subjective and objective intestinal stiffening, the former being recognized only by the patient as a colicky pain, the latter being recognized by visible movements of the intestinal walls as they rise over one another like serpents within the abdomen. The illustration (Fig. 387) made in a case of dynamic intestinal obstruction illustrates well this visible contraction. Sometimes the phenomenon of intestinal stiffening is almost the sole symptom to call attention of the patient to the advancing disease.

Tumors of other abdominal organs and structures may give rise to pressure symptoms that may lead to confusion.

The non-malignant tumors are also to be excluded, and a discussion of their diagnostic relations has been presented already.

The treatment of these tumors constitutes one of the most important and interesting fields of abdominal surgery. Their relative non-malignancy makes their management more gratifying.

The symptoms of stenosis not infrequently are the most prominent phenomena calling for relief. English surgeons are very fond of colostomy to relieve this difficulty and to prolong life by preventing the irrita-

tion of the affected parts. Colostomy may be performed for the purpose of temporarily relieving the bowel of distention and allowing the secondary lesions to disappear. For this purpose intestinal exclusion, either incomplete or complete, may be practised as a preliminary to excision. At the cecum, however, it is usually best to remove the affected bowel at one sitting. This is preferably effected by the method laid down under the heading Resection on p. 722. The ends of the remaining intestine are closed by invagination sutures, as a lateral anastomosis provides for the fecal current.

Mikulicz describes a method by which he obtained eleven recoveries in twelve operations which he styles the *Verlagerungs-Methode*. It consists in partial eventration of the affected bowel, ligation of its meso-

Fig. 387.—General Peritonitis; Intestinal Obstruction; Excessive Visible Peristalsis. My own case, published previously by Bayard Holmes.

colon, including the diseased glands, and closure of the wound about the protruding bowel for from thirty-six to seventy-two hours, when with the Paquelin cautery the diseased part is amputated. Two weeks later the artificial anus is dealt with by the use of Mikulicz's modification of Dupuytren's clamp.

Care is to be exercised in operations of this kind that the patient shall not lose his life during or after the operation by the regurgitation or vomiting of fluid and its inhalation in such a way as practically to cause drowning.

S. C. Plummer [45] reports the following case treated by the method of von Mikulicz:

Woman, forty-two years old, married, mother of four children.

The family history was negative, except that one sister died of tuberculosis. The personal history included the statement that eleven months previously the patient suffered from what was apparently dysentery. Since that time she had had several attacks of partial intestinal obstruction. In the left iliac region could be felt the bowel, the thickened walls of which rolled under the examining finger. By vaginal examination a hard mass, palpable high up in the pelvis, was felt on the left side, apparently having some connection with the uterus, but rather freely movable. As rectal examination was negative, it was thought that the obstruction of the bowel was in the lower part of the sigmoid.

Laparotomy was performed by vertical incision through the left rectus muscle, extending upward from Poupart's ligament. A hard tumor was found bound down to the posterior abdominal wall. This tumor was about 1½ inches in diameter, with a well-marked constriction at its middle. A loop of the ileum which was adherent was loosened, and a slight thickening upon it was removed with scissors. The left Fallopian tube, with its ovary, was attached to the mass and had to be separated. The mesosigmoid was now divided close to the abdominal wall, having first been seized with forceps. Opposite the middle of the mass, the mesosigmoid was involved and much shortened. This part was allowed to remain attached to the growth after being separated from the adjacent portion of the mesosigmoid. After ligating the cut surface of the divided mesosigmoid, the tumor could be brought out through the abdominal wound. The left tube and ovary were now removed. The cut edges of the sound mesosigmoid and the adjacent surfaces of the two limbs of the loop involved leading up to the tumor were now stitched together, except in the immediate neighborhood of the tumor. The tumor and adjacent portion of the loop being now held outside of the abdomen, the parietal peritoneum was stitched to the loop of bowel all the way around, and the remainder of the peritoneal incision closed. The fascia and skin were then united, except where the loop escaped. A longitudinal incision was now made in the proximal portion of the loop, and a glass tube tied in by means of a running stitch of catgut. A dressing was applied.

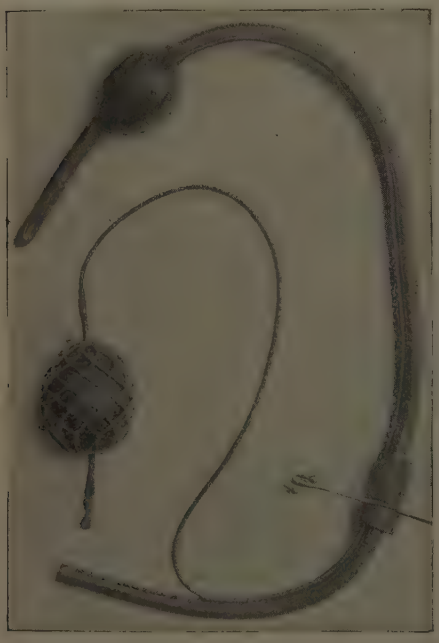

FIG. 388.—KAUSCH'S ORIGINAL ESOPHAGEAL NARCOSIS-TUBE FOR THE PREVENTION OF FECAL DROWNING (Willy Meyer).

Two days later, under gas anesthesia, the tumor was cut away with scissors. Six days later a large artery forceps was applied to the spur between the two limbs of the bowel. Two days later it came away, bringing the piece of necrotic tissue with it. The artificial anus produced was closed later, the bowel having been loosened from the surrounding tissues and the open ends sewed together. The patient made an excellent recovery.

INTESTINAL OPERATIONS.

Essential Principles.—There are a few essential principles which it is necessary for the operator thoroughly to have mastered in order successfully to carry out the various manipulations of intestinal surgery. These principles are simple, few in number, easily grasped, and susceptible of application in actual practice with means that are at hand under almost all conditions. Except under direst stress of emergency, one should not perform surgical operations upon the intestines of the human subject without first having studied the matter experimentally upon the lower animals. For this purpose the intestines removed from dead animals may be employed, though the actual manipulations upon the living animal are of greater value, since the result of the work can be determined in somewhat the same way as would be the case in actual practice upon human subjects.

The ordinary seamstress' sewing-needle with silk thread can be used in almost all cases of intestinal operations with perfect success and with a mortality as low as that which can be attained by the use of any mechanical device, provided only the operator has grasped the principles of the art and put them in practice upon the lower animals.

Halsted, of Baltimore, long ago suggested a very simple mode of preparing the intestinal needles required in this work. Taking a sewing-needle of ordinary size, No. 6 to No. 8, and threading it with the strongest available silk cut to a length of 14 inches, 2 inches being allowed for the short side and 12 for the long, the sutures are lightly sewed into gauze or a towel at a distance from one another of about a quarter of an inch; one or two dozen armed needles may thus be sewed into one piece of cloth. The cloth may then be rolled up and placed in the sterilizer to be removed and unrolled when required for use.

It is often urged that the operators do not possess the requisite skill to use the needle and thread. If this is true, it should be added that such a man should not do surgical work. It is absolutely essential, whether one uses mechanical devices or not, that he be skilled in the application of sutures through long practice.

Preventing the escape of infectious fluids during the operation is of prime importance. Kocher deserves great credit for showing that long artery forceps may be used for this purpose without risk of gangrene if only so much pressure is applied as is required to prevent the escape of intestinal contents. If the edges of the wound at the point of clamping are completely turned into the lumen of the bowel before

the suturing is completed, the clamps may be compressed sufficiently to lock them if this be desired. If now we can apply clamps or forceps to the bowel without undue fear of gangrene, it will be seen that the organs may be handled so far as is necessary with great ease and without excessive risk of leakage and the flooding of the peritoneum.

Hemorrhage from the incisions in the organ must be carefully controlled so that bleeding shall not take place to an excessive degree, either at the moment of making the incision or for the next thirty-six hours. Beneath the mucosa are large veins and arteries which, lacking substantial support by dense connective tissue, can easily bleed into the bowel for hours after the operation is finished. To guard against this it is essential that the deeper stitches grasp all vessels that open upon the wound surface in such a way as permanently to close them. In order that the suture shall make sufficient pressure upon the vessels, it is necessary to tie or lock the suture at very short intervals.

Gangrene must be avoided by leaving no suture or other device to make constant elastic pressure upon the edge of the organ to the point of strangulation. Even where sutures are applied in intestinal work the parts of the bowel edges tightly embraced in the grasp of the suture must inevitably die, and in this way the suture, if of silk, be thrown off into the lumen of the bowel. This, however, is a very different matter from constriction of the bowel in such a way as to bring about a gross destruction of its walls, rendering it subject to bacterial invasion which may end in a spreading gangrene or inflammation that may cause death by leakage of intestinal contents or hemorrhage. The larger blood-vessels of the intestines involved must, of course, not be compromised. In cases of resection it is of the greatest importance to leave intact the large arteries and veins that supply the parts which are subject to surgical interference. It is better to sacrifice a little more intestinal tissue than to run the risk of gangrene of a large part of the loop from the injudicious sacrifice of important vessels.

Contraction of the scar tissue which inevitably occurs after all intestinal operations must be reckoned with. The amount of scar tissue produced when such devices are used as the intestinal button of Murphy is very small. In successful cases this, of course, is a great advantage. The peritoneum adheres to peritoneum, muscularis soon becomes united with muscularis, and the mucosa becoming continuous, it is often almost impossible to detect the line of union. But during the period of healing the narrowness of this line of peritoneal union is a source of extreme danger to the patient. One of the most important services performed by Nicholas Senn in his numerous writings on intestinal surgery is his insistence upon the use of broad peritoneal surfaces wherever the escape of infectious fluids is to be regarded as one of the hazards of the operation. Our greatest safeguards in abdominal operations lie in the rapid absorption of peritoneal fluids and the swift adhesion of properly approximated peritoneal surfaces. The use of those devices which depend for their characteristic success upon the application of extremely narrow areas

of peritoneum is associated with an inherent unavoidable violation of one of the most important laws of abdominal surgery.

Having decided that we will apply broad surfaces of peritoneum to one another, we must make sure to make provision for very extensive contraction. This can easily be done by making the artificial openings from two to four times as long as the opening needs finally to be.

Enterorrhaphy.—The paradigm of intestinal operation is enterorrhaphy. Most of the principles involved in intestinal surgery may be studied and put into application in the simple closure of wounds of the bowel. When the bowel is to be incised, it may be remarked that the incision should preferably be made upon the free surface of the tube, that is, at a point farthest away from the mesenteric attachment. If this is not done, and if the cut is made near the mesentery, that portion of the wall of the bowel lying between the incision and the free border may have its blood-supply compromised, wound healing may take place imperfectly, or gangrene may result. When such a wound is to be closed, a strong suture must be used to bring together all the coats of the bowel at once. For this purpose I frequently use a heavy twisted silk in needles somewhat larger than ordinary sewing-needles and provided with spear points. Ordinary needles of large size may be used if desired. The *Czerny suture*, as it is called, is then applied as follows: The bowel being held up between thumb and finger and the neighboring operative field having been protected by large pieces of gauze made into the form of compresses, the needle is passed through all the coats of the bowel at one end of the incision; the needle naturally enters the lumen of the bowel, and passing through it and through the opposite side of the intestine as well, practically transfixes the bowel wall. The first loop of thread is tied snugly, then successive sutures are passed in the same manner through the edges of the wound, the operator being careful to hold the needle perpendicular to the edge of the wound, to enter the needle well back from the edge of the wound, and to include all the coats of the bowel, especially the mucosa. After making three or four sutures a knot must be tied in order that too much of a purse-string action may not be obtained. Instead of this knot I frequently use a device for locking which I believe is original with myself. This consists in entering the point of the needle at a spot an eighth or a quarter of an inch back of the insertion of the last preceding suture, passing the needle through the bowel wall diagonally, in such a

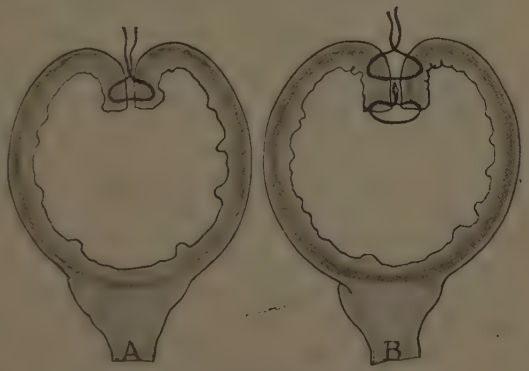

FIG. 389.—INTESTINAL SUTURES (Kelly-Noble). *A*, Lembert suture; *B*, Czerny-Lembert suture.

manner that the loop of silk goes through the preceding loop that lies within the bowel wall. The effect of this maneuver, it will be seen, consists in making a knot within the intestinal wall, and it will be found that traction upon the suture can no longer produce a puckering of the wound edges. The process of passing sutures and occasionally locking is con-

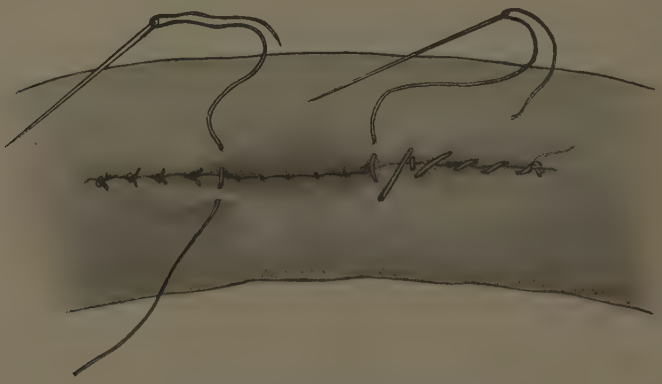

FIG. 390.—THE LEMBERT STITCH (Gould).
The interrupted stitch is shown on the left, the continuous stitch on the right. The apparent irregularity in the continuous stitch is due to its not yet having been pulled tight.

tinued until the wound is entirely closed, when a final knot is made, and the suture cut short at both ends. A stream of hot salt solution (temperature 100° to 115° F.) is to be applied in order to wash away infectious matter. The operator's hands are disinfected and the Lembert sutures are next applied. The objects of the first layer of sutures were as follows: to prevent escape of intestinal contents; to prevent hemorrhage; mechanically to support and maintain in apposition the intestinal walls.

FIG. 391.—LEMBERT INTERRUPTED STITCH, WITH CROSS-SECTION (Gould).

The object of the *Lembert sutures* is to bring together surfaces of peritoneum which, having the power of rapidly adhering, will produce within a few hours a barrier to the spread of infection from the line of sutures that passes through the intestinal wall. For this reason, then, the Lembert suture must be applied with great care. Beginning at one end of the wound, the needle is passed through the peritoneum down to the fibrous coat of the intestinal wall; a bit of this is picked up with the point of the needle, the direction of the needle is changed, so that pressure upon the blunt end causes it to emerge from the peritoneum, holding within the grasp of the thread a portion of peritoneum and a bit of fibrous

tissue. The peritoneum has but little mechanical resisting power, and it is the fibrous tissue which makes it possible to bring together peritoneal surfaces without passing the needle into the lumen of the bowel. It is of minor importance in what direction the needle is pointed into the coats of the bowel for this purpose. As a rule, however, where continuous Lembert sutures are used, the needle is kept parallel to the wound edges. Where the suture is interrupted, it may be applied in a direction perpendicular to the line of the wound, especially if the so-called mattress sutures are to be used. I advise the use of the simplest forms of suture, especially those already described, since extensive practice in the use of a few sutures will give much greater skill in their application. The Lembert suture may be interrupted by knots as frequently as seems necessary in order to prevent a puckering of the line. This is of especial importance where, as is often the case, it is desired to apply a third line of sutures in order to prevent peritonitis from leakage, since, if the sutures were not interrupted by locking, each successive line of stitches would contract the line of incision still further. At the close of this work the bowel should again be washed with hot salt solution.

Fig. 392.—Lembert Continuous Stitch with Cross-section (Gould).

Other well-known sutures for enterorrhaphy are the following: Halsted's mattress stitch (Fig. 393), Cushing's right-angled stitch (Fig. 394), and Connell's suture (Figs. 395, 396, 397). They need no detailed description, since the pictures furnish an adequate idea of the method of application.

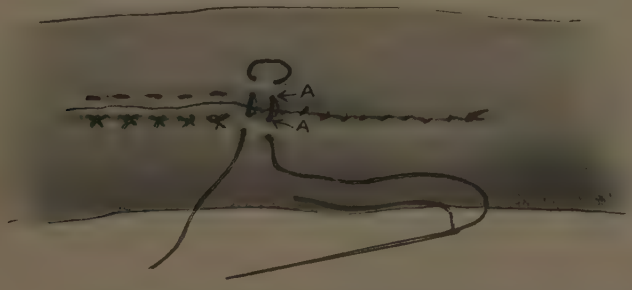

Fig. 393.—Halsted's Mattress Stitch (Gould).
A drawn to A.

Intestinal Anastomosis.—The simplest form of anastomosis performed on the gastro-intestinal tract is that involving two parts of the small intestine.

The portions of the bowel to be united having been chosen with care and so arranged that peristaltic waves in the two portions will be in the same direction and the fecal current will not be deflected from its course, a line of Lembert sutures with frequent locks or knots is to be so applied as to unite the sides of the selected loops at a distance from the free border of the bowel equal to one-third or three-fourths of its circumference. As this preliminary layer of Lembert sutures is to form the outer barrier against peritoneal infection, each extremity of its line is to be curved toward the free border of the bowel and the ends of the threads are to be left long. Since there is but little to resist the force of scar contraction in the bowel, it is desirable to make the anastomotic opening

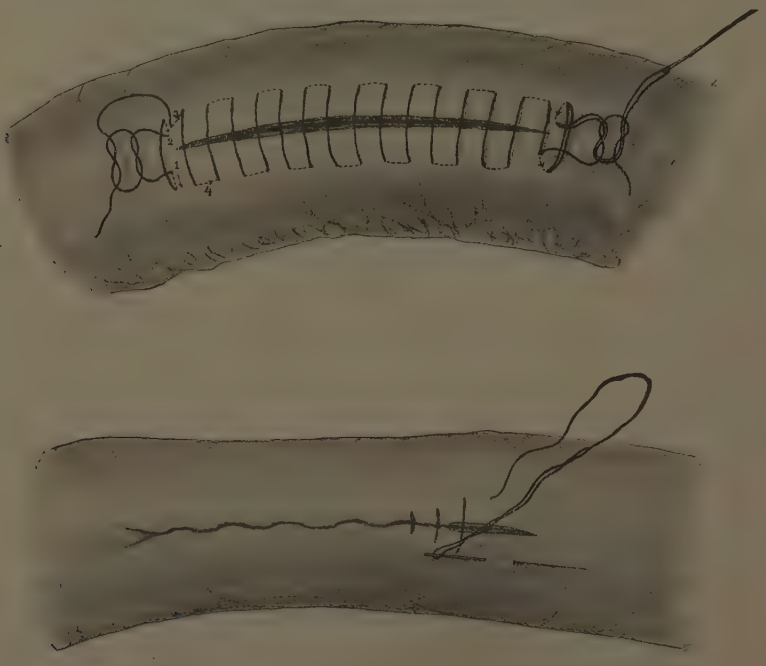

FIG. 394.—CUSHING'S RIGHT-ANGLED CONTINUOUS SUTURE (Kelly-Noble).

at least two and one-half times as long as would be necessary if this contraction were not expected. The loops of bowel may be grasped by a long artery forceps or clamp in such a way that the tissues through which the incisions are to be made are held in its grasp. The purpose of this forceps is at once to hold the bowel and to prevent the escape of intestinal contents when the incisions are made. If the forceps are not closed with undue severity, there will be no danger of gangrene.

Now, with the knife or scissors make an incision in each coil as nearly as possible in the line of its free border; if the forceps has been rightly applied, there will be neither hemorrhage nor escape of intestinal contents. With a larger needle with armed heavier silk, apply the Albert Lembert stitches with frequent locks or knots to unite firmly the cut edges at all

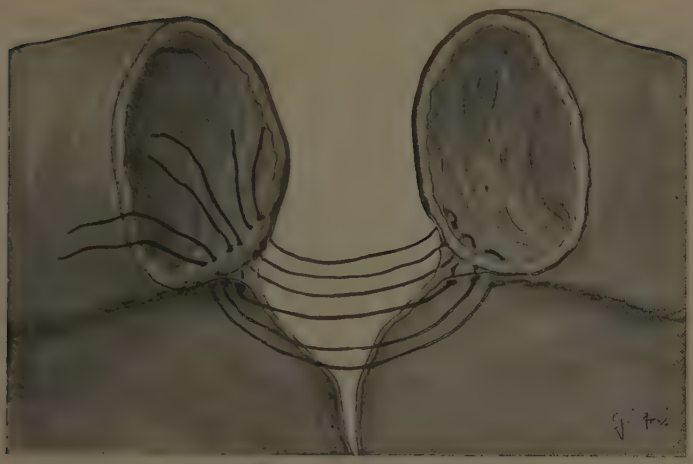

FIG. 395.—CONNELL SUTURE (Gould).

Shows method of placing the three mattress mesenteric stitches. For the sake of clearness these stitches have not been tied, although, actually, each stitch should be tied as soon as it is introduced.

points. Care should be taken to apply locks or knots at the points where a change is made in the direction of the line of sutures. Wash off the bowel with hot salt solution without allowing the wash-water to flow over the remainder of the operative field. Complete the line of Lembert sutures by the use of the needle and thread left attached to the original Lembert sutures. A second layer of Lembert stitches may be applied if desired, but it is not necessary if the first layer has been well placed.

Connell's mattress stitch for end-to-end anastomosis is illustrated in Figs. 395, 396, and 397.

The formation of an anastomosis between the small and large intestines presents a problem in the differing diameter of the tubes to be united. It must be remembered that the stitches through the

FIG. 396.—CONNELL'S SUTURE (Kelly-Noble).

Knots applied within the lumen of bowel; starting the second row.

larger organs must include a relatively large amount of tissue in the case of the Albert stitches to guard against mechanical rupture (distraction) and consecutive hemorrhage; in the case of the Lembert sutures, to afford sufficient grasp of the subperitoneal tissues to avoid yielding of the line.

McGraw Elastic Ligature.—In May, 1891, T. A. McGraw, of Detroit, Michigan, published the results of a study of the use of elastic ligatures in gastro-intestinal surgery for producing anastomoses between parts of the tube. After much experimentation McGraw worked out a satisfactory technic for the production of openings between these hollow organs with the aid of continuous elastic constriction.

A continuous row of Lembert sutures is so placed as to bring together the intestinal peritoneal coats in a line beyond the proposed point of anastomosis, the ends of the suture being left uncut. This first preliminary line of sutures is to form the outer line of defence against infection. Next an elastic suture of rubber which is threaded into a heavy needle is passed through all the coats of each bowel, successively, into the interior of the tube; the needle is carried along through the bowel to a point near the end of the preliminary line of silk sutures, where it is forced out of the bowel again. The same thing is repeated in reverse direction, producing in this way a loop of elastic ligature which embraces the part which is to produce a new opening. The elastic ligature is then firmly tied, after having been drawn tightly together, and the knot itself secured by a heavy silk ligature. Next a Lembert silk suture is applied about the periphery of the field of operation, the elastic ligature having been cut short.

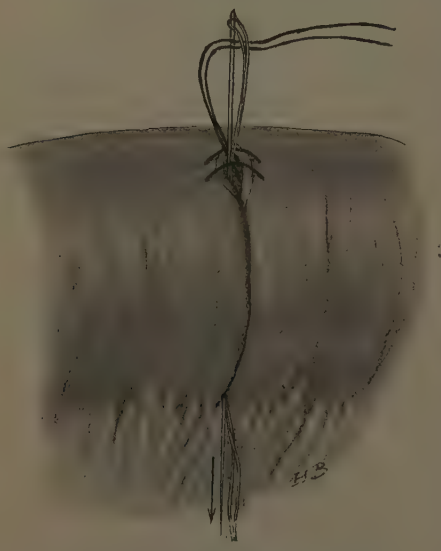

FIG. 397.—CONNELL'S SUTURE (Kelly-Noble). Method of inserting needle for tying the last knot.

A large anastomotic opening can be made in this way, 2½ inches of bowel wall being easily included in the grasp of the ligature. McGraw lays stress upon the choice of a proper ligature. He says it should be a firm, hard, round, rubber cord at least 2 mm. in diameter, of the very best quality of rubber. A rubber thread or flat band will not act as a proper substitute. Nelson, Baker & Co., of Detroit, have recently had molds manufactured for the production of ligatures tapering at the end.

The elastic ligature making continuous pressure upon the bowel wall

causes necrosis and gangrene, which soon sets free the ligature, which floats down the intestinal track.

FIG. 398.—LATERAL ANASTOMOSIS BY THE MCGRAW LIGATURE (Gould).

The first seromuscular stitch has been placed. The rubber ligature has been introduced with two needles. Note knot on left (Murphy) in middle of rubber ligature, to increase the speed of the cut-out.

Results by this method have been very satisfactory to those who have used it. The advantages of the operation are numeruos, not the least being the fact that the danger is very slight, owing to the fact that the bowel is not extensively opened during the operation so that infection is not likely to occur. It is rare that the anastomotic opening has to be made patent at the moment of operation. In a case of that kind the McGraw ligature would be unavailable; where conditions are not pressing, the ligature offers an excellent method of procedure, especially for inexperienced operators. It has the advantage over metallic instruments that the ligature can pass away without risk of producing intestinal obstruction, ulceration, hemorrhage, and other accidents.

FIG. 399.—LATERAL ANASTOMOSIS BY THE MCGRAW LIGATURE (Gould).

The ligature is being drawn taut, thus dragging the two knots together. Note method of depressing the first seromuscular suture with the blunt end of forceps. Note position of silk tie which is to secure the knot in the rubber ligature from slipping.

FIG. 400.—LATERAL ANASTOMOSIS BY THE MCGRAW LIGATURE (Gould).

This shows the three stages of the technic. On the right the first seromuscular continuous stitch is visible, while, to its left, the intestine is puckered up by the rubber ligature, which has been tied tight and cut close. On the extreme left are seen the interrupted seromuscular stitches with which the whole front of the joint will be closed in.

Jejunostomy. — In a variety of lesions of the stomach the production of a jejuno-cutaneous fistula has been frequently suggested and practised. The fistula is useful in nourishing the patient artificially when the stomach is no longer pervious and cannot be rendered pervious by operation, when the stomach is incapable of performing its functions of digestion, and when that organ is the seat of disease which would be aggravated by the presence of food or its passage through it. The indications for the operation are discussed in the chapter upon the diseases of the stomach. H. Lempp[46] has very fully considered them in a recent article. The technic of the operation is described in Vol. III, pp. 942–944.

Appendicostomy. — Appendicostomy is the name applied by Weir to making an opening in the appendix after having withdrawn its free end through an abdominal incision, and fixed it there. The technic of the operation is very simple. The ordinary incision through the abdominal wall having been made, the appendix is drawn up to the skin and fastened to it by suitable

FIG. 401.—APPENDICOSTOMY (Moynihan).

The incision in the skin is made long to show the details of the operation. It need not be longer than 1 to 1½ inches when the operation is performed during life.

sutures through the peritoneal coat and through the skin. The appendix may be immediately opened and a tube may be passed into its interior, or the opening may be deferred for twenty-four or thirty-six hours.

Weir and others have found appendicostomy of great service in washing out the bowel when chronic inflammatory processes demand irrigation of that part of the tube.

Colostomy.—The most frequent indication for the production of a colostomy or artificial communication between the colon and the skin, allowing the fecal matter to be discharged externally, instead of requiring it to pass through the remainder of the bowel is to be found in those diseases, such as carcinoma and sarcoma, which permanently impair the functions of the rectum and anus.

By fecal fistula is understood an opening which, though it allows fecal matter to pass out upon the skin, does not necessarily force all of the material to pass in that direction.

A fecal fistula is useful at times in temporarily relieving pressure in the intestines, and in partially diverting the fecal current outward rather than downward. The fecal fistula may be easily produced by making an incision over the cecum as for appendicitis, or in the left inguinal region, bringing the large intestine up to the wound and attaching the peritoneal edge to the wall of the bowel by means of an ordinary Lembert suture. The bowel may then be opened, and its cut edge united to the fascia or to the skin. If the bowel is sutured to the skin, a permanent mucocutaneous fistula is likely to result, while if one sutures the bowel to the fascia instead of the skin, the fistula can be more readily closed when no longer required.

If no pressing need for relieving the interior of the bowel from pressure is at hand, the bowel need not be opened for twenty-four or thirty-six hours after it has been stitched to the parietal peritoneum. The danger of peritonitis, which in any case with careful work is not great, is in this manner reduced almost to nothing.

Where it is desired to deflect the entire contents of the bowel outward and to prevent all irritation from this source from occurring lower down, an artificial anus is best provided. This is effected by entirely transecting the bowel after fixing it in a wound of the abdominal wall. If the wound is made by separating muscle-fibers instead of cutting them, an action somewhat like that of a sphincter is provided. This, however, is not often necessary, as patients demanding such an operation are, as a rule, in a deplorable condition, from which they are to be speedily released by death.

I have frequently made use of the following modification of the very simple method of Maydl.

Under gas or ether or local anesthesia make an incision from 1½ to 3 inches in length, depending upon the thickness of the abdominal wall, over the colon at the point desired; draw a loop of the bowel up out of the abdomen, and pass through its mesocolon a rod the size of a lead-pencil, of glass or wood, rolled up in gauze, and allow its ends to project on each side, resting on the abdominal wall. In this manner the colon is fixed

in the abdominal wound under a heavy dressing for twenty-four or thirty-six hours, when it may be opened with the scissors without anesthesia, allowing the escape of the intestinal contents. At that time or even later it may be wholly divided and, if one desires, the lower end of the bowel may be entirely closed by suture.

This operation can easily be performed upon patients who are very much emaciated and extremely weak without much fear of loss of life.

Treatment of Linear Gangrene.—Crampe has made an extended study of the subject of gangrenous linear grooves upon the wall of the intestine, produced by the pressure of bands or of hernial sacs. While he is of the opinion that in a certain percentage of these cases it is admissible to sew over the peritoneum from neighboring parts of the bowel, he warns against applying the principle too freely.

In cases where gangrene has already occurred, the method proposed and executed by myself will be of value, since a practically unlimited amount of peritoneum can be drawn upon, owing to the splitting of the intestinal wall in a longitudinal manner opposite the mesenteric insertion.[49]

Resection.—The importance of closing the slit in the mesentery after all operations requiring such an opening to be made has long been recognized. Körte called attention to this requirement in 1895. Braun described a case of internal strangulation after intestinal resection due to this cause. A similar case was reported by Heidenhain, the occlusion occurring after resection of the colon for carcinoma.[50]

The simplest and most effective method of resecting the bowel consists, in my opinion, in the immediate closure of the cut ends and the restoration of continuity between the remaining portions of the bowel at a new point. This of course means the establishment of a lateral or side-to-side anastomosis instead of making an end-to-end union. I am convinced of the desirability of this method because tissues are utilized which have not been mutilated and therefore damaged or infected, and because much of the work, namely, the application of the peritoneal stitches, can be effected before the tube is opened. Furthermore, it is often possible to lift out of the abdominal cavity these portions of the bowel, whereas an end-to-end union is often difficult because the part cannot be withdrawn. The technic of resecting the bowel and permanently closing the part to be left has been simplified in my practice to a very considerable degree. The technic is a modification and amplification of Kocher's suggestion.

Apply upon the intestine at the point where the bowel is to be divided a long artery forceps compressing the entire intestine, set at such an angle to its border as will insure a good blood-supply to the edges of the wound. By the sides of the first forceps place two others as close to it as possible. Remove the first forceps and transect the bowel with a knife as closely as possible to the forceps which is placed upon the part of the bowel to be removed. Wrap up in a laparotomy compress the cut end of the bowel which is to be removed in order temporarily to protect the operative field from infection. Now, with a continuous heavy suture whip over the end of the intestine which is to remain. This suture

is a continuous one without locks or knots. When the suture has been applied but not fastened, have the assistant remove the forceps. Then draw the suture tight to form a purse-string, and tie the end. Wash the end of the bowel with a stream of salt solution. Disinfect the hands and invert the line of sutures just described into the interior of the bowel by means of a continuous Lembert suture without knots or locks.

Repeat the same process upon the bowel at the other side of the part to be resected.

The portion of the bowel to be removed may now be excised after preliminary ligation of the mesenteric blood-vessels, preferably at a point near the bowel, in order to prevent interference with the blood-supply of the remaining intestine. A lateral anastomosis may now be made.

FIG. 402.—RESECTION (Moynihan, after Kocher).
The mesentery is ligated off close to the gut.

After-effects of Extensive Enterectomies.—A. E. Barker[51] gives three cases illustrative of the condition of the small intestine some years after extensive enterectomies. There must be few surgeons now who do not recognize the peculiarly disastrous effects of paralysis of the bowel in advanced intestinal obstruction. But few of us are likely to have many opportunities to see the effect of this paresis on the living gut years after the relief of severe obstruction.

Two of these patients, both women, were operated on years ago for gangrenous femoral hernia, and in both Barker was obliged to resect long tracts of small intestine in order to obtain relatively sound tissue for the anastomosis. Both made satisfactory recoveries, but were readmitted for operations in the course of which it was possible to examine the original seat of the enterectomies. In both it was most interesting and instructive

to observe that though the communication between the two portions of the bowel was perfect and as wide as possible, the afferent or proximal portion still showed unmistakable signs that it had not yet recovered its former tone as contrasted with the efferent or distal portion, which was normal. The significance of this observation appears very great, from both a medical and a surgical point of view, and so far as Barker knows, has not yet attracted attention. These two observations made *intra vitam* fill up, to a certain extent, a gap in our knowledge as to the changes which take place in an intestine above an acute obstruction, and as to the period during which these effects may remain after the latter has been relieved. It might at first sight appear almost incredible that evidence of want of tone in the bowel should exist several years after the cause has been removed. This fact, which Barker was able to demonstrate to his class, drives us to the conclusion that in acute strangulation we must operate before these changes have had time to develop, and if this be impossible, we must not hesitate where resection is necessary to remove large tracts of bowel in order to get well above the paralyzed portion, saturated as it is with toxins and thus devitalized.

Intestinal Exclusion.—By intestinal exclusion we understand the diversion of the fecal current by a short cut away from a certain limited part of the intestine. If the exclusion is effected by making a fistulous opening (anastomosis) between the loops of bowel above and below, we consider the exclusion partial or incomplete, since a portion of the fecal matter may still find its way into that part of the bowel which is thrown out of the direct fecal current. By complete exclusion we understand that both the proximal and distal ends of the excluded loop of bowel are closed by invagination sutures. The excluded part of the bowel has occasionally been left entirely separated from both the remainder of the alimentary canal and also from the skin, and a number of instances are recorded in which this procedure has given rise to no grave consequences. The majority of experienced surgeons counsel against so radical a maneuver, on the ground that infectious matter has no exit and that perforation may take place, especially in cases where ulceration and other destructive processes are going on in the infected loop. In the main it is wiser to leave the excluded part in communication at some point with the remainder of the bowel or with the skin. If the latter method has been followed, but a small amount of discharge will take place after the first few days and the patient will not be seriously inconvenienced by the fistula. In carcinomata of the colon otherwise inoperable, intestinal exclusion, which has been so strongly advocated by v. Eiselsberg, will be found to have many beneficent applications. The surgeon, however, must not be tempted by the simplicity of the procedure and the relief and comfort which it gives the patient to neglect the possibilities of resection where it is feasible.

The technic of exclusion consists merely in permutations of procedures already described. Following Prutz, we may call the lumina of the bowel which are exposed by transection above and below the part to be excluded, Nos. 1, 2, 3, and 4, counting from above downward. After transection the lumina 1 and 4 may be closed with a lateral anastomosis between the

proximal and distal parts of the intestine, while lumina 2 and 3 may be treated after one of the following methods (Prutz): (1) Both are sutured into the skin; (2) the upper end is dropped, the lower end sutured into the skin; (3) the reverse procedure is practised; and (4) both are dropped, (*a*) after each end has been closed, or (*b*) after the ends have been united.

Unilateral exclusion, that is to say, the operation of transecting the bowel, permanently occluding the end of the distal portion and implanting the proximal end at a point remote from the site of section, is open to an insuperable objection, rendering it a method unfit for recommendation. Haberer[50] has made an extensive study of this subject under the direction of von Eiselsberg. It will easily be seen that, in order to make the end of the proximal part of the bowel approach the point of implantation, it will be necessary to nick the mesentery and that, after the implantation, a gap will exist below the mesentery of the implanted part through which it will be easy for coils of intestine to pass, making obstruction an easy accident. It is far better, therefore, to make a side-to-side anastomosis instead of an end-to-side apposition.

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CHAPTER LXIII.

SURGERY OF THE APPENDIX VERMIFORMIS.

By John B. Murphy, M.D.,

CHICAGO.

TYPHLITIS, PERITYPHLITIS, EPITYPHLITIS.

A great many keen clinicians observed and studied cases of appendicitis at the end of the eighteenth and the beginning of the nineteenth century, but their incorrect nomenclature and the lack of a definite knowledge of the anatomy and primary pathology of the tissues involved, as well as their inability to interpret the relationship between the clinical symptoms and the underlying pathologic processes, make their voluminous records almost useless. An epoch-making advancement in the history of appendicitis begins with Reginald Fitz, of Boston. To Fitz belongs the credit and honor of having given a masterly description of the disease, of having introduced the term appendicitis, and, particularly, of having been the first powerful advocate of timely surgical intervention. The literature following Fitz's forceful article would make a library in itself, but a careful analysis and discrimination may exclude most of it, leaving only a few classic articles, among which we mention those of Bull, Krafft, McBurney, Murphy, Deaver, and later those of Sonnenburg, Krönlein, Roux, and a few others. It is neither wise nor permissible to exhibit patriotism in science, but one cannot help stating that America was the pioneer in the advancement and elucidation of perityphlitis and appendicitis, and particularly that she has taken the lead in bringing its surgical treatment to its present high standing as a life-saving procedure.

Historical.—In 1867, Willard Parker, of New York, successfully treated four cases of appendical abscess with phlegmon of the abdominal wall, by a simple incision and evacuation of the pus. In 1873, W. T. Bull published a valuable article on "perityphlitis" based on an analysis of sixty-seven cases. Seven years later, With, a Norwegian, published an article the title of which suggests its contents, namely, "Peritonitis Appendicularis." Four years later a remarkable step was made by Mikulicz, who in a powerful address urged laparotomy in perforations of the stomach and intestine. All these periods and events bring us to the writings of Fitz and Gaston, of America, and Krafft, of Lausanne. In an article published by Fitz in the "American Journal of Medical Sciences" in 1886, he showed that the clinical picture in two hundred and ninety cases of typhlitis and perityphlitis closely resembled that of two hundred and fifty-seven cases of perforation of the appendix, and

distinctly pointed out that the appendix is responsible for most abscesses occurring in the right iliac fossa. He makes it clear that the variations in the clinical picture depend to a great extent upon the anatomic variations of the appendix, its position, length, etc. Fitz wished to call attention to inflammation of the vermiform appendix as the *primary* lesion, and that to which treatment was to be directly applied. But perhaps the greatest credit that Fitz deserves is for the powerful manner in which he urged early surgical intervention. An equally powerful advocate was Gaston in this country and, as mentioned, Krafft, of Lausanne.

The more recent writers, in reviewing the history of appendicitis, have confined themselves to a review of articles published under the caption "Appendicitis," and have therefore omitted the important and, indeed, creative works published under the headings "Phlegmon of the Right Iliac Fossa," "Intra-Abdominal Abscess," "Pericecal Abscess," "Epityphlitic Abscess," "Perityphlitic Abscess," "Perityphlitis Vermicularis," and "Perityphlitis." Indeed, the last was the title of many able papers in which the keenest insight as to the etiologic and pathologic conditions, clinical manifestations, and surgical indications and operations were most forcefully outlined long after Fitz had suggested the name of appendicitis, but before it was generally adopted. The perityphlitic pathologic changes were regarded as the most important features of the disease, the appendix being considered the *locus minoris resistentiæ*. The change in name from *perityphlitis* to *appendicitis* was not a change in our medical knowledge, but a change in the accentuation of the etiologic factor, in place of the gross pathologic processes. The monograph of Krafft, which followed those of Fitz, Bull, and Robert F. Weir, but immediately preceded Murphy's and McBurney's, generated the greatest surgical activity. Murphy, in a paper read before the Chicago Medical Society, November, 1889, in which he reported eight cases, made the following plea for early operation: "It is our conviction that before many years every case of perityphlitis when diagnosed will be immediately operated, the appendix ligated, if possible, and amputated. This operation gives the only guarantee, that a patient can have, of safety from the impending danger of the disease and security against its return." These statements preceded the publication of McBurney.*

The old operation was performed in the presence of phlegmon of the abdominal wall, which included the period to 1888, with the exception of desultory cases of removal of the appendix in conditions other than acute inflammations. One of this class was operated by Marcy, of Boston, 1876, and one by McBurney, May 21, 1888—"a retention suppurating cyst of the appendix." In contrast with the old operation, the modern surgical procedure is that based on the diagnosis of infection of the appendix and pericecal tissue before the manifestations of phlegmon or fluctuation, and had its origin in 1888 and 1889. This was the basis of Murphy's action and declaration quoted above; his first operation was March 21, 1889. The masterly work of American surgeons in this field deserves splendid commendation. The pioneers in other countries are Reclus,

*McBurney: New York Medical Journal, Dec. 21, 1889.

Roux, Talamon and Dieulafoy in France; Hancock, Treves, Kelynack, and Lockwood in England; and Krönlein, Mikulicz and Sonnenburg in Germany.

In the struggle for priority, Thomas G. Morton, of Philadelphia, and Sir Frederick Treves each claim to have first removed the appendix in 1877, but in neither case was it for the acute infective variety as now understood. In many publications Krönlein has been given credit for making a definite diagnosis of appendicitis and deliberately operating for its removal. This is not in accordance with the facts. He made the diagnosis of "intestinal obstruction or peritonitis" and operated; in sponging out the pus he found the appendix free from adhesions with a perforation near its base; he tied the mesentery and stump of the appendix and cut it off; the patient died three days after from collapse.

Anatomy.—"The vermiform appendix," says Paul Reclus, "is the diverticulum of a diverticulum, the cecum of a cecum." It is the undeveloped part of the cecum, corresponding to the *long terminal portion* of the latter found in the lower animals.

The appendix, in addition to being pushed to the left, is apparently carried back by predominating growth of the anterior wall of the cecum. Hence it usually branches off (in about 90 per cent.) from the inner or inner and posterior wall of the cecum, about one inch below the lower border of the ileum where the latter enters the large bowel.

The direction taken by the appendix is so variable as to defy classification. When not adherent it may occupy a number of positions. Lafforgue, for example, found it hanging into the pelvis in 41.5 per cent. of two hundred cadavers of all ages and both sexes; pointing toward the spleen in 26 per cent.; resting on the iliacus in 17 per cent., and retrocecal in 13 per cent. Other observers give the retrocecal as the most common, etc. For all practical purposes it may be said that in over one-half the cases the appendix points either *up* and *in*, or *down* and *in*.

These figures relate to the cadaver. Mariau points out that there is nothing to prove that the appendix occupies during life the position it is found in at the necropsy. "The appendix is very mobile," says this author, "and may occupy, even in the same subject, all sorts of positions according to whether it and the cecum are distended with gas or empty."

In addition to four or five positions of the organ which may be termed normal, there are several abnormal ones; for example, its presence in a hernial sac or in one of the cecal fossae (twelve times in one hundred and four subjects—Lockwood and Rolleston). When the cecum remains in its primitive fetal location in the left iliac fossa, the appendix will be on the left side (Fig. 403).

As a result of the free movements of the appendix, it may become adherent in various locations—to the omentum, mesentery, parietal peritoneum, the rectum and bladder, or the internal genitalia of the female. Finally, a fistulous communication may be established be-

tween the adherent appendix and other parts of the bowel, *e. g.*, the cecum, ileum, or rectum.

The size of the appendix is as variable as its position. The length is from 1 to 9 inches (Wister, Luschka) or 9½ inches (Trevor, Georgieff). The average length as established by several thousand measurements is 3.6 inches. In the fetus and new-born child the organ is relatively longer. In the adult female it is about one-half inch shorter on the average than in the male. The diameter averages one-fourth inch at the base and one-fifth inch at the middle and tip. The diameter affords no index to that of the lumen, for the walls vary much in thickness. The appendix is sometimes, though rarely, absent (Zuckerkandl, Lafforgue, Swan).

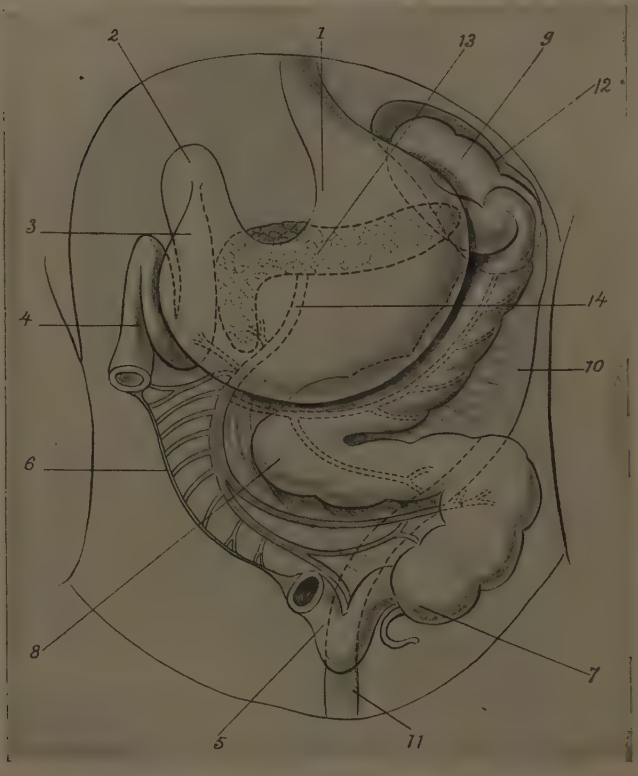


FIG. 403.—APPENDIX LOCATED ON THE LEFT SIDE (Gronroós).

1, Stomach; 2, first part of duodenum; 3, vertical part of duodenum (dotted); 4, beginning of jejunum; 5, end of ileum; 6, section of the common mesentery; 7, cecum; 8, angle formed by colon; 9, splenic flexure; 10, descending colon; 11, rectum; 12, spleen; 13, pancreas; 14, superior mesenteric artery.

The appendix is provided with a mesentery of its own—the mesoappendix or mesenteriolum. This, like many other of the folds of the peritoneum, is due to a lifting of a fold of peritoneum by the blood-vessels in the fetus as they course along. It comes off the left or lower surface of the mesentery of the ileum at its termination, and, passing behind the latter, runs along the appendix. In the fetus it extends to the tip, as it does in over one-half of the adult subjects; when too short it causes the appendix to become curled upon itself. In the fetus and young child the mesoappendix is thin and translucent; in the adult it contains much fat, especially in corpulent individuals. Between its layers are also found unstriped muscle-fibers, the appendicular artery and its branches, with the ac-

companying veins, nerves, and lymphatics, and one or more lymph-nodes.

The lumen of the appendix opens into the cecum about one inch below the ileocecal valve. This opening is funnel-shaped, as a rule; occasionally it is a mere slit or a circular orifice. It is sometimes partly closed by a fold of mucous membrane, discovered by Weitbrecht, but known as Gerlach's valve. It is evident that this must be rudimentary, or flatus or feces could not enter the appendical lumen. Moreover, it is by no means constant; for instance, Lafforgue met with it but twice in his two hundred cases.

Since the classic researches of Ribbert, we know that the lumen of the appendix may become wholly or partially obliterated. This observer found this process commencing as early as the fifth year, and it was present in over 50 per cent. of the subjects over sixty.

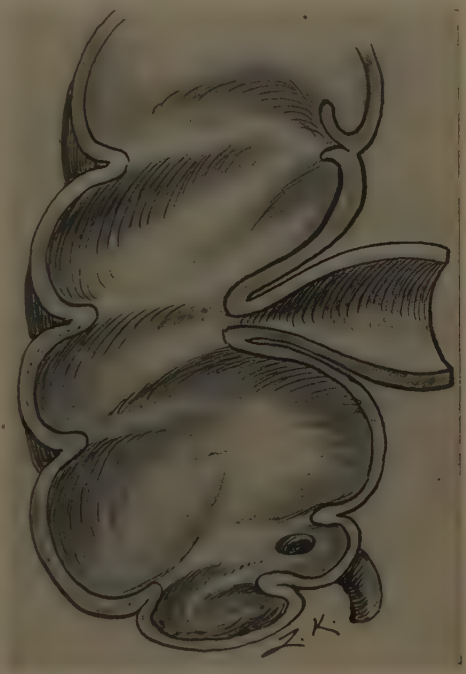


Fig. 404.—Showing Relation of Appendix to Ileocecal Valve.

Total obliteration was observed by Ribbert in 3.5 per cent. of the cases. This corresponds very nearly to the figures of Lafforgue (3 per cent.) and of Lockwood and Rolleston (4.5 per cent.). Total obliteration was not observed by Ribbert before the age of thirty, and it is most frequent after sixty. Partial obliteration was observed in over one-half the cases, to a degree involving one-fourth of the length of the appendix. The length of the appendix is also of considerable influence in the production of occlusion. Ribbert found, other things being equal, that occlusion was more frequent in the short appendices than in the long ones.

Arteries.—The appendicular artery, a branch of the posterior ileocecal, runs down behind the ileocecal angle, crosses the ileum (hence is liable to be compressed by fecal masses in the latter), and reaches the appendix at a variable distance from its base. It then runs in the free border of the mesoappendix to the tip, giving off a few branches in its course; these vary with the length of the appendix, from two, three, or four, to seven or eight. While the appendicular artery anastomoses with the cecal artery, the communicating branches are extremely minute, and the circulation may be said to be terminal. The branches of the

artery run in the subserous coat, and supply both walls in the same manner as the branches of the superior mesenteric do the small intestine. Hence when the mesoappendix does not extend along the whole length of the appendix, the terminal portion has a poor blood-supply. Moreover, as in the small intestine, that part of the appendix nearest the mesentery is better provided with blood than is the opposite side. The base of the appendix is supplied, in addition, with blood from twigs of the cecal branch of the posterior cecal artery. This is the only source of blood-supply to the appendix in the fetus before the mesoappendix forms.

Veins.—The veins accompany the arteries. They are very thin-walled

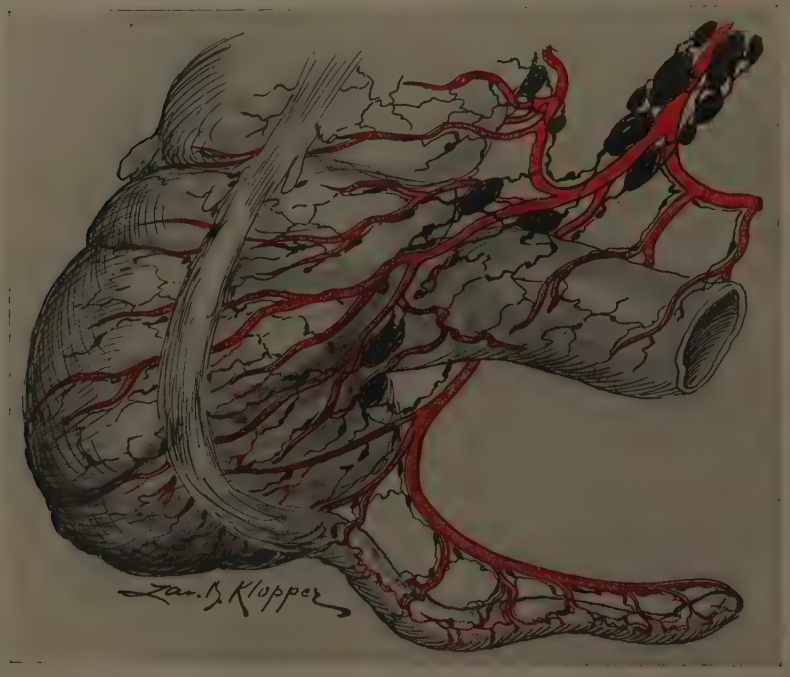


FIG. 405.—SHOWING THE ARRANGEMENT OF THE ARTERIES AND LYMPHATICS OF THE VERMIFORM APPENDIX AND ILEOCECAL REGION.

and are among the most dependent branches of the portal system (the hemorrhoidal and sigmoid alone being lower). It will be noticed that the blood-supply of the appendix is very precarious and readily liable to interruption.

Lymphatics.—These accompany the blood-vessels and empty into a lymph-node which is rather constant at the ileocecal angle. It is occasionally found some distance away in the lower portion of the mesentery, and is then not distinguishable from other mesenteric glands, of which it is, in this event, the lowest.

Nerves.—The appendix has a rather abundant nerve-supply from the superior mesenteric plexus of the sympathetic system.

Structure.—The appendix has been compared to a Peyer's patch thrust out from the bowel like the finger of a glove, and so comprising all the coats of the large intestine.

The *serosa* or peritoneal coat is continuous with the serous covering of the mesoappendix, and entirely surrounds the organ save where the mesoappendix is attached. It is very thin, from $\frac{1}{50}$ to $\frac{1}{25}$ inch thick, and adheres to the muscularis by connective-tissue fibers.

The *muscularis* is composed of two layers—the longitudinal is from $\frac{1}{50}$ to $\frac{1}{25}$ inch in thickness, though it varies at different ages. The circular layer, which is nearly continuous, is about $\frac{1}{25}$ inch thick (also varying greatly according to age). At the base of the organ the fibers of the two layers cross, forming a network.

The *submucosa*, which varies more in thickness than any of the others, is composed of connective tissue which supports the blood-vessels, lymph-vessels, and nerves. The lymph-follicles from the mucosa often extend into this layer. The thin muscularis mucosæ divides this layer from the innermost coat.

The *mucosa* is made up principally of lymphoid tissue with tubular glands and lymph-follicles embedded in it, with a single layer of columnar epithelium resting on a thin basement membrane. There are, in addition, the blood-vessels, lymph-vessels, and nerves.

The lymphoid tissue has very recently been the subject of a paper by Berry and Lack. From their researches it seems there is practically no lymphoid tissue in the full-term fetus; the lymph-follicles, too, are absent. Within the first two weeks, two or three well-marked lymph-follicles appear, and lymphoid tissue is scattered profusely throughout the whole mucosa. In a month more the number of lymph-follicles increases to from eight to twelve, and the lymphoid tissue is now seen infiltrating the mucosa and submucosa. At the age of thirty-two weeks the appendix is, to all appearances, an actively functionating gland. In a cross-section are seen ten or a dozen well-marked lymph-follicles and about one hundred and sixty tubular glands. The lymphoid tissue also tends to disappear, beginning in most cases about middle age. Unlike the follicles, however, it never totally disappears (Berry and Lack).

Surface Landmarks.—The familiar McBurney's point was thus first described by its distinguished discoverer:

"I believe that in every case the seat of the greatest pain determined by pressure of the finger has been very exactly between an inch and a half and two inches from the anterior spinous process of the ilium in a straight line drawn from that process to the umbilicus. This point indicates the situation of the base of the appendix where it arises from the cecum, but does not by any means demonstrate, as one might conclude, that the chief point of the disease is there."

Keith, who investigated the topography of the appendix for Sir Frederick Treves, prefers Munro's point, which nearly corresponds to McBurney's point, but is more precise. In a young adult this is found by drawing a line about 6 inches long from the anterior superior spine to

the umbilicus; where this crosses the outer edge of the rectus is Munro's point, and is about 2.6 inches from the iliac spine.

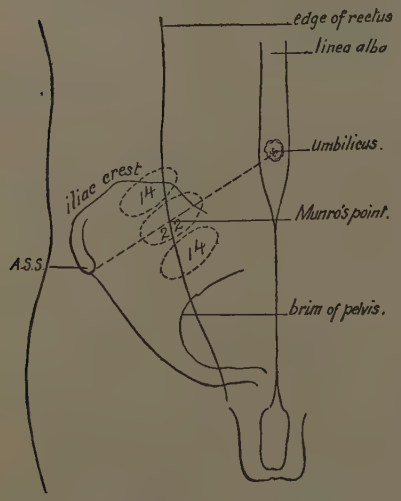


FIG. 406.—SHOWING DIAGRAMMATICALLY THE POSITION OF THE ILEOCECAL VALVE IN FIFTY SUBJECTS (HARDENED BY FORMALIN) (Keith).

The structure most frequently found precisely under Munro's or McBurney's point is the ileocecal valve. In twenty-two cases the valve was immediately below or near Munro's point, in fourteen above and external to it, and in fourteen below and internal (Keith). As already stated, the appendix is, on the average, about one inch below the valve.

After the abdomen is opened the appendix can be located at the ileocecal angle, or the cecum lifted up dragging the appendix with it, unless the latter be adherent. The longitudinal muscular layer of the large intestine is collected into three flat bands or teniæ—the anterior or omental, the posterior or mesocolic, and the internal or free. Of these, the anterior, when traced down to its commencement, will lead to the base of the appendix. This means, however, will be of little assistance when, as is so often the case, the structures are inextricably matted together by adhesions. The appendix when not readily found may be herniated, as will be presently shown.

Pericecal Fossæ.—There are several fossæ or pockets in the peritoneum about the cecum, and the appendix may be lodged in either of two of them and thus be hidden from view (retroperitoneal hernia of the appendix). In many cases it can be readily extricated; in others the orifice of the fossa becomes closed by adhesions and the organ is found with the greatest difficulty. This condition of affairs was probably the case in many examples of so-called "absence of the appendix." It is believed that inflammatory phenomena are more likely to originate

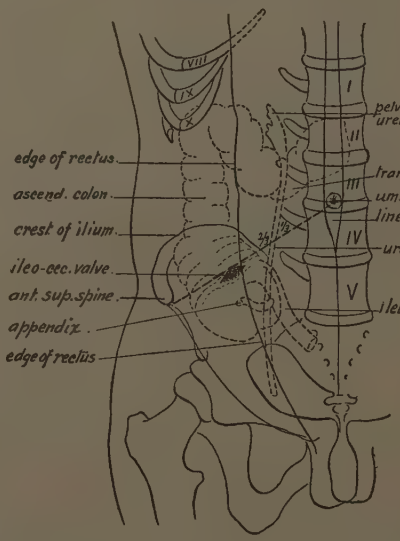


FIG. 407.—AVERAGE POSITION OF THE ILEOCECAL VALVE, CECUM, AND APPENDIX ON SPINO-UMBILICAL LINE (Keith).

in such herniated appendices, in which case the abscess is essentially retroperitoneal.

These fossæ are the ileocecal or ileo-appendicular, and the subcecal or retrocolic. The former, situated in the ileocecal angle, is bounded in front by a fold of peritoneum—the ileocecal fold (bloodless fold of Treves), behind by the mesoappendix, and above by the end of the ileum. The orifice looks down and to the left; it is quite large, as a rule, admitting two fingers as far as the first joints, and is found in nearly every subject. Hernia is most frequent into this fossa.

The subcecal fossa is bounded in front by the posterior walls of the ascending colon and cecum, behind by the peritoneum of the posterior

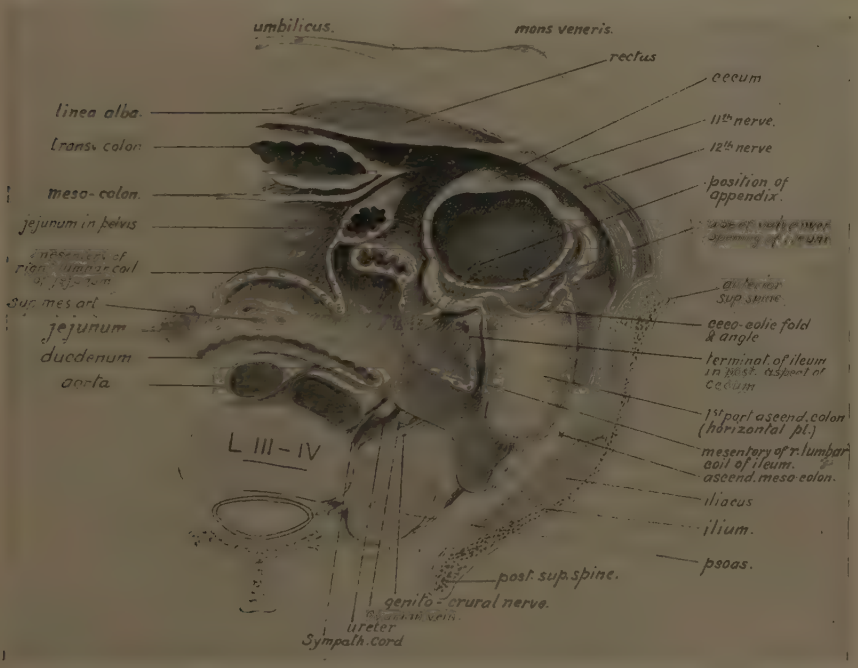


Fig. 408.—Oblique Transverse Section of Female Subject through Anterior Superior Spine, Umbilicus, and Disk Between Third and Fourth Lumbar Vertebræ (Keith).

abdominal wall; the lateral boundaries are made up of folds of peritoneum. This is of good size also, an inch or so in each direction.

Etiology.—While physicians are positive thinkers, their imaginations are often vivid. This is well exemplified in the writings on the etiology of appendicitis. In text-books the writer is compelled, for the sake of completeness, to enumerate the prominent theories which have been expounded.

Sex.—There is no particular reason why there should be a difference in the frequency in the two sexes, notwithstanding the fact that in our experience there were more males than females. In the experience of Sonnenburg of a thousand cases of appendicitis, 67 per cent. were males.

In a series of Roux, of six hundred and seventy cases 53 per cent. were males. Barbier's six hundred and sixteen cases included 76 per cent. males. Out of Deaver's three hundred cases 61 per cent. were males.

Age.—Appendicitis is rare in infancy, very common in young adults, fairly common in middle life, and unusual in the aged. The prevalence of the disease in children and adolescents is explained by the fact that during the period of growth the lymphoid structures are overactive in their development, which may be the cause of their involvement. The diminution in frequency in later life is due to a more careful diet and more rational mode of living; furthermore, to the fact that adenoid structures have atrophied, the lumen of the appendix has gradually contracted and in this way excluded the possibility of admission of fecal matter and foreign bodies.

Appendicitis was believed to be more common in the United States, and its prevalence has been attributed to the strenuous life and the lack of proper attention to eating. This is not in accordance with the facts; *it has not been more prevalent, but was more uniformly recognized, more heroically and conservatively operated* by American physicians and surgeons than by any other. Indeed, it was ironically called in many European clinics the "American disease." The laity of this country appreciate the danger of delay and consequently demand early surgical relief, which, no doubt, is an important factor in increasing the number of cases operated and, thereby, the number of lives saved in America.

Family Appendicitis.—It is an established fact that appendicitis is more prevalent in some families than in others. This hereditary tendency is probably due to a peculiar conformation of the appendix or to diminished resistance to infection, and, no doubt, to the fact that the mode of life and diet of the individuals are similar. On the other hand, certain families seem to have a comparative immunity against the disease. We have repeatedly operated on two or more members of the same family and, not infrequently, within a short period of time.

Trauma.—In 1892 we called attention to the fact that trauma is occasionally an exciting factor. In an analysis by von Neumann from Bramann's clinic, trauma figures ten times among one hundred and fifty-two cases as an etiologic factor either from a direct injury to the abdomen or from lifting. While trauma from without is not of very great importance, we consider irritation of fecal concretions of great significance in the causation of appendicitis. The mechanical theory has its advocate in Talamon. He states that if the lumen is obstructed by fecal concretions the wall of the appendix contracts and the glands of the mucosa become hyperactive, throwing out a greater quantity of fluid, and, as it has no exit, it dilates the lumen, presses upon the blood-vessels, and in this way interferes with proper circulation; furthermore, the stasis of the fluid constitutes an excellent medium for the bacterial flora of the intestine, the virulence of which is greatly increased under these circumstances. Dieulafoy considers appendicitis a result of the occlusion of the appendix, either by calculi, foreign bodies, or stricture; even a simple edema of the mucosa may be capable of obstructing the lumen. The micro-organisms

become very virulent if they are retained under pressure. This statement is confirmed by the experiments of Klecki, who ligated the mesentery of the appendix and induced in this way a passive hyperemia. The harmless colon bacilli were considerably increased in virulence when venous stasis was present. According to him, it is not necessary that the appendix should lose its patency in order to have an increase in virulence, as any cause which produces venous stasis is sufficient to increase the infection, irrespective of the occlusion of the lumen. Foreign bodies, kinks, and twists favor venous stasis. Pozzi mentions the possibility of occlusion by Gerlach's valve. While the presence of a foreign body is unquestionably unfavorable, it may be present for months and years without producing erosion, the atrium which admits micro-organisms into the intercellular spaces of the mucosa causing inflammation.

The proximity of the appendix to other inflamed organs very frequently produces what may be called secondary appendicitis; for example, an appendix situated in the pelvis in intimate relationship with an inflamed tube or ovary or with a pelvic exudate, regardless of its origin, with infected cysts of the broad ligament or of the ovaries, may become secondarily affected. This is illustrated time and again in gynecologic work where a pathologic appendix is included in the diseased structures of the pelvis. No doubt in many cases it is either difficult or impossible to say whether the appendicitis was the primary or a secondary infection, but the more extensive involvement of the pelvic organs, in addition to a suggestive history as to primary involvement of the adnexa, will facilitate the differential diagnosis. Inflammations of the appendix are frequently secondary to those of the gall-bladder, as emphasized by Dieulafoy, but the reverse has been our observation. Appendical infection, next to typhoid, is the most common etiologic factor in cholelithiasis and cholecystitis.

Intestinal parasites—amœba coli, for instance—have occasionally caused appendicitis. Among two hundred autopsies in children under twelve years of age, Still found oxyuris in thirty-eight cases, twenty-five of which contained the parasite in the appendix, the latter showing evidence of catarrhal inflammation. Metchnikoff reported a few cases of appendicitis due to parasites; Monash observed in his own practice and collected a number of cases of this class; others have since reported cases.

Diet.—Lucas-Championnière (1904), in an analysis of 22,000 patients among Roumanian peasants, found but one case of appendicitis; they live mostly on vegetables. The Roumanians living in the city, chiefly on animal diet, are frequently affected; one case of appendicitis among every two hundred and twenty-one patients. The vegetarian diet of the Japanese and of the Indians of India seems to protect them against appendicitis. The absence of appendicitis among the Arabs living in tribes and on vegetables, with its prevalence among those in cities, where meat is the chief diet, has already been spoken of.

Golubof considers appendicitis as an infection *sui generis* resembling follicular tonsillitis. Sir James Grant and Henry M. Lyman see a relationship between rheumatism and appendicitis. Finney and Hamburger

state that articular involvement may be present either during or preceding an attack of appendicitis.

According to Sonnenburg, appendicitis is more frequent during epidemics of la grippe. This is an orderly sequence of the numerous general intestinal infections from that disease. Constipation, which is considered by many an etiologic factor, is entirely ignored by Deaver.

Ochsner observed attacks of appendicitis in children as the result of some indiscretion in diet. In almost every case which came under his observation the condition was previously diagnosed as acute gastritis, and only after the symptoms became very serious, was the proper diagnosis made.

FIG. 409.—EARLY GANGRENE OF THE APPENDIX OVER A FECAL CALCULUS; APPENDIX OPENED.

The **bacteriology** of the appendix was entirely unknown until 1891, when its study was undertaken by Adenot and Guillioud in France. The nature of the infection in the appendix can be studied in various ways: first, by making smears or cultures from its contents; second, by blood-cultures. The smear has the advantage of giving immediate results and also of showing all varieties of bacteria that may be present in the lumen, whereas the culture is inaccurate unless carefully plated, as the colon bacillus has the cultural peculiarity of overpowering other micro-organisms during growth, and therefore a culture is an insufficient evidence of the bacterial flora of the appendix. Blood-cultures are of value when the infection has invaded the general circulation; in other words, in septicemia.

The natural agent of infection in most of the cases of appendicitis is the colon bacillus, as it is the normal guest of the large intestine, in a semi-saprophytic state. It is capable of increasing its virulence under circumstances already mentioned, but one should not forget the cultural peculiarities above indicated which make the bacteriologic records quite misleading.

In our experience the order, as concerns the flora of the appendix, is the following: bacillus coli communis, staphylococcus pyogenes aureus and albus, streptococcus, pneumococcus, bacillus tuberculosis, actinomyces.

The streptococcus is often the agent of fatal peritonitis, either alone or associated with other micro-organisms. Symbiosis is unfavorable for its growth. The virulence of the streptococcus is very variable and upon it depends, to a great extent, the degree of sepsis.

The range in variety and virulence of the micro-organisms is very limited and much less than is usually supposed, as the intestinal contents are uniformly subjected to practically the same treatment in the process of digestion. Nearly, if not all, of the micro-organisms and spores are destroyed in the stomach, except those whose normal habitat is the intestinal tract. This accounts for the regularity and uniformity as to time, degree, and toxicity of the infections resulting from appendical and intestinal perforations, and the uniformity with which good results can be obtained by timely and intelligent intervention.

Pathology.—Until the last quarter of the nineteenth century most of the clinicians thought that the primary origin of the pathologic process was in the cecum.

The pathologic process may involve one, two, or all the coats of the appendix. In the catarrhal form the mucosa alone is involved. It has lost its rosy appearance and the folds are either swollen or have disappeared. In many instances, in the acute form of appendicitis, if the appendix is removed before the neighboring coats are grossly involved, diffuse petechial hemorrhages have taken place into the submucosa, and glisten through the mucous membrane. These petechial hemorrhages always correspond to a marked leukocytic invasion of the mucosa, submucosa, and muscularis, and are gross evidence of the acuteness of the process. In cases operated in from three to eighteen hours after the onset of symptoms, this is often the only indication of disease, presenting the picture of an intense, acute granular ophthalmia; here the process may entirely subside, through intra-intestinal drainage.

Where the infection is more intense and the edema and infiltration of the mucosa more extensive, there is a rapid local or general gangrene of the mucosa.

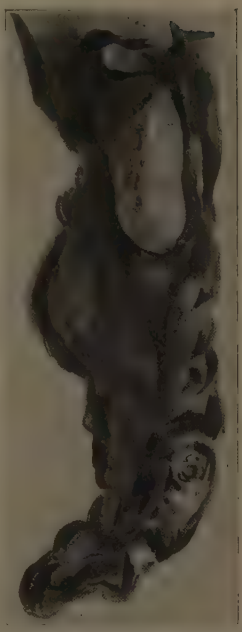
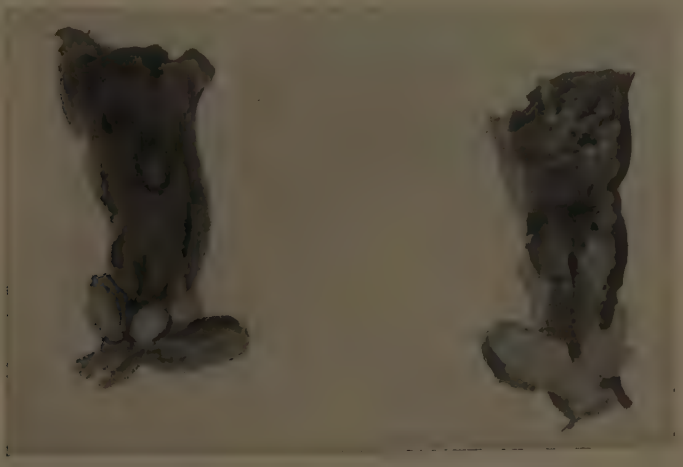


FIG. 410.—EARLY PERFORATION OF APPENDIX OVER THE DISTAL OF TWO CALCULI. GANGRENE OVER BOTH.

The rapid destruction of the appendical mucosa or entire wall is due to three elements, in the following order of importance:

First: The presence of pus—type not significant—under tension causes an



A *B*

FIG. 411.—SHOWING A PERFORATION INTO THE MESENTERY.
A, External appearance; *B*, from the mucous surface with the appendix opened.

ischemia of the edematous and infected mucosa, which increases the toxic and biotic destructive effect of the micro-organism.

Second: Virulence of the micro-organism hastens the destruction.

Third: Pus products in all parts of the body are rapidly absorbed when held under tension; there is also more rapid destruction of tissue. The inelasticity of the wall of the appendix contributes to this high tension. The ischemia produced by the compression favors the rapid invasion and early biotic and toxic necrosis of the tissues. Complete gangrene of the mucosa has been observed as early as seven hours after the initial colic (Fig. 409). The gangrenous process may involve all of the walls in a circumscribed area, or all of the appendix from tip to base (Fig. 410). This strangulation is not due to occlusion of the artery, but to an ischemia from the local pressure of the accumulated products.

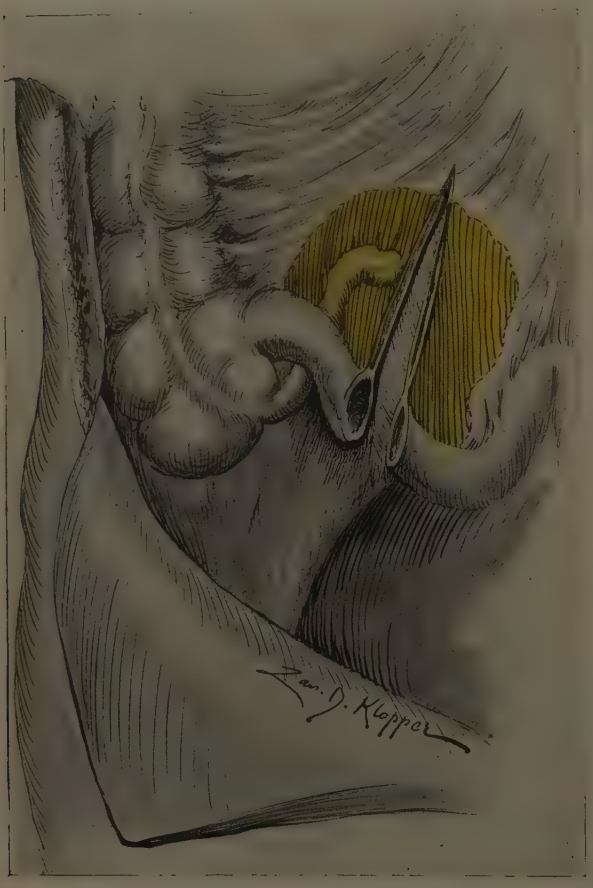


FIG. 412.—ILLUSTRATING MESENTERIC ABSCESS.

If the lumen contains a fecal calculus or foreign body, the pressure of this causes an ulceration or gangrene of the segment surrounding it and tends to very early perforation at this point.

The gangrenous zone may be surrounded or supported by adhesions, or, if rapidly formed, may remain exposed in the free peritoneal cavity until such time as the gangrenous tissue separates from the living and permits the escape of the appendical contents into the peritoneal cavity.

A milder type of infection often produces a suppuration of the mucosa, with retention of the pus, the submucosa and muscularis showing a mild infiltration only and no tendency to gangrene, but often perforation into the mesoappendix, which is the place of least resistance. It results in a mesoappendical mesenteric abscess (Fig. 412); the point of perforation may be not larger than the eye of a darning-needle, and when the edema and swelling of the appendix subside, the abscess may drain (Fig. 411) through the appendix into the cecum. The appendical wall may perforate through other portions than the mesoappendical margin and cause a circumscribed intraperitoneal abscess or a peritonitis.

The pus may invade the retroperitoneal or retrocecal tissues and produce what has been called a phlegmonous retroperityphlitis or extraperitoneal fecal abscess. This pus may find its exit through the posterior abdominal wall; into the free peritoneal cavity; into the intestinal tract; or it may form a circumscribed abscess and remain weeks or months encapsulated.

The above descriptions refer to the acute process. In the chronic form the lumen is partly obliterated by adhesions or as a result of hyperplasia; the mucous membrane is then rather fibrous in appearance. It may contain one or several calculi. The appendix now assumes various shapes, depending upon the position in which the external adhesions fix it to neighboring structures. In places it is constricted or flexed by adhesions and the constriction corresponds to an obliteration of the lumen. Its wall may be infiltrated, its neck occluded, and a retention cyst may have developed. The tip of the appendix may become adherent to distant organs, as the female genitalia (see Fig. 413), the rectum, liver, gall-bladder, spleen, etc. In many instances it may be so displaced and distorted that a careful dissection is required in order to restore its original position. Occasionally the tip may be adherent to the iliac

FIG. 413.—VERMIFORM APPENDIX ADHERENT TO RIGHT OVARY AND TUBE WITH ABSCESS IN THE PELVIS.

vessels, as normally they are in close proximity. Now and then, the appendix may be entirely absent, as the result of auto-amputation, a sequence of destructive pathologic processes. It may be found adherent with its tip on some distant organ and the base floating free in the abdominal cavity, or the appendix may have become gangrenous and been eliminated through the bowel with the pus.

The appendix may be the seat of a tuberculosis, with the same clinical manifestations as in the acute infections, or with symptoms of chronic appendicitis. In every case of suspected tuberculosis either the ocular or hypodermic tuberculin test should be made. In the former one drop of a 1 per cent. solution of Koch's tuberculin (old) in normal salt solution is dropped into the conjunctival sac; the

first symptoms of a positive reaction appear in from six to twelve hours usually, though they may be delayed for twenty-four hours or more. Their presence is indicated by a "scratchy" feeling, secretion and redness of the inner canthus, caruncle, or conjunctiva, disappearing entirely in from one to three days. If for any reason the test is to be repeated soon, the opposite eye must be used, as the previous use seems to sensitize the conjunctiva and diagnostic errors may result. This is a most reliable and harmless method, as a healthy individual gives no reaction. The hypodermic injection of 5 mg. of the old tuberculin produces a typical constitutional reaction causing malaise, headache, and an elevation of temperature to 101°, 102°, or even 103° at the end of twenty-four hours. In an additional twenty-four hours these symptoms entirely subside. It occasionally causes the symptoms of an acute appendicitis when the appendix is tuberculous, as observed by Neff.

Foreign Bodies and Calculi in the Appendix.—Fecal calculi are composed of feces, salts of calcium and magnesium, mucus, and desquamated epithelium; the nucleus may be a foreign

FIG. 414.—CICATRICIAL OBLITERATION OF THE APPENDIX, ENCAPSULATING FECAL CALCULI.

FIG. 415.—ATROPHY OF MUCOSA PRODUCED BY CALCULUS NOW FREE IN THE LUMEN.

body. Calculi may be single or multiple; they may be loose in the lumen (Fig. 415), firmly impacted, or encapsulated in scar tissue (Fig. 414), and upon this depends the integrity of the mucous membrane.

In my cases foreign bodies, seeds, gall-stones, capsules, etc., were present in a little less than 2 per cent. of the cases. Fecal concretions were found in 38 per cent. of the acute cases operated. Fitz found fifteen concretions in three hundred cases. In four hundred and fifty-nine autopsies analyzed by Ranvier, there were one hundred and seventy-nine concretions and sixteen foreign bodies.

Adhesions around the appendix are very common and are permanent

records of antecedent pathologic changes. There seems to be, in some individuals, a tendency to extensive adhesions irrespective of the degree of inflammation, the disproportion being occasionally very striking. In operating on a case in which the diagnosis was chronic appendicitis, the patient having no history of an acute attack, her suffering having been comparatively moderate, still, on opening the abdomen, the appendix was found embedded in strong adhesions, and almost every square inch of colon and ileum for some distance from the appendix was firmly matted by adhesions. The separation required a very extensive dissection and subsequent filling of the peritoneal cavity with nitrogen gas to prevent recurrence. Whenever these adhesions are found at operation, one can usually elicit from the patient a definite history of an abdominal inflammation treated under some other name than appendicitis.

Adhesions between the appendix and visceral peritoneum do not, as a rule, cause pain; it is the adhesions to the parietal peritoneum only which produce pain. Many patients recover from an attack of appendicitis without its having been recognized as such. Among five hundred autopsies analyzed by Taft, 36 per cent. showed evidences of an attack of appendicitis at some time during life. Among thirty-seven hundred and seventy autopsies at the Boston City and Johns Hopkins Hospitals three hundred and twenty-five, or 8.62 per cent., presented adhesions around the appendix.

M. Letulle, after studying over one thousand human appendices, concludes that in the adult almost no appendix is ever perfectly normal. In all, at some point of the organ, the submucous follicles appear large, thickened, proliferated, deformed, and deforming the tubular glands. These points are surrounded by a sclerotic zone, a relic of past inflammation, without direct relation to the terminal disease. Very often the muscularis mucosæ is more dense and thickened. Finally, the vasculo-connective tissue making up the submucosa is thickened, condensed, and has lost its fat cells. Acute perforating appendicitis then develops in the major number of cases in an organ previously attacked. Operated appendices often present an appearance called "hemorrhagic folliculitis." This lesion, which is found only in the operated appendices, is the sequence of the violent ligation of the organ before its ablation; it is a follicular apoplexy.

Many observers in clinics have criticized the operators for removing "normal" appendices based entirely on the gross appearance at the time removed. The above facts given by Letulle show how indiscreet and ill-founded such comments are.

The topography of a pathologic appendix is very different from that of the normal. In about 50 per cent. of the acute cases we have found the appendix in the pelvis, and in a large proportion of these the abscess was entirely confined to the pelvis and not always to the right half. The appendix is rarely found behind the peritoneum, although retroperitoneal abscesses are not rare, due to perforation and not to malposition of the appendix. Many times it is embedded in the wall of the caput coli, posteriorly, a position always pathologic, never anatomic. In the intermediate operations, as well as in the acute stage, it is occasionally found attached to the ileum. Twice we found it strangulated and gangrenous in a femoral hernia, and a number of times in the acute and intermediate operations in inguinal hernial sacs. A pathologic appendix may be situated on the left side, either in cases of transposition of viscera,

or without such transposition. We found the entire appendix to the left of the median line in two cases. In one it was adherent to the left tube and in the second to the transverse colon. In many of the acute, and even in the intermediate cases, the tributary lymph-nodes in the mesentery are enlarged. Occasionally they may suppurate, even after the subsidence of an attack. In chronic appendicitis the organ shows an infiltration and thickening of the walls, which, together with enlarged lymph-nodes, may suggest either malignancy or tuberculosis; it is therefore imperative to dissect out one or two lymph-nodes for diagnostic purposes. An appendix which has been subjected to repeated inflam-

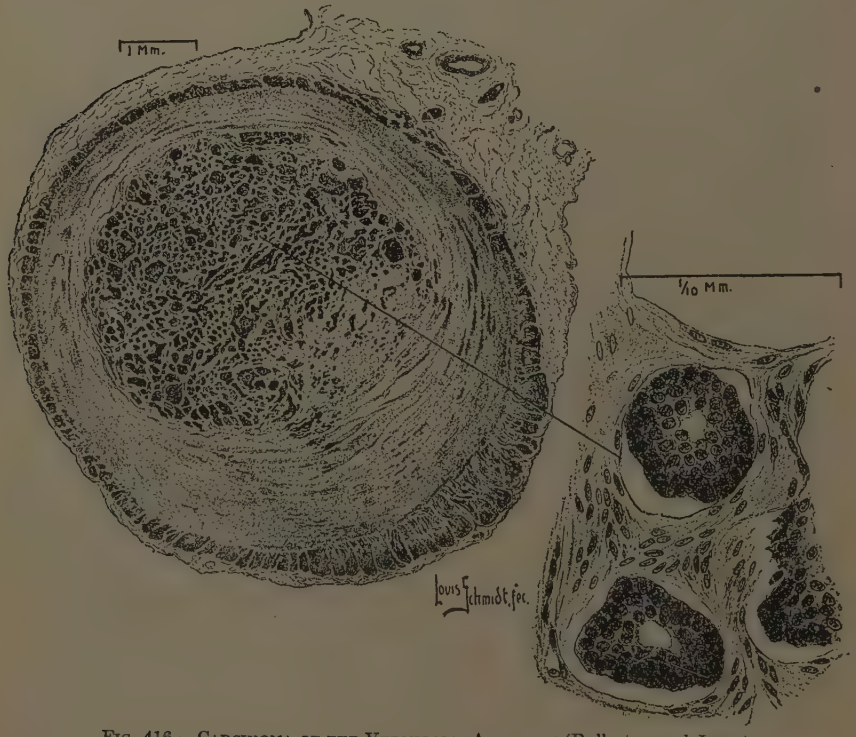


FIG. 416.—CARCINOMA OF THE VERMIFORM APPENDIX (Rolleston and Jones).

mations, especially in individuals past forty, may be partly or totally obliterated. In other words, obliteration may be the sequence of repeated pathologic processes in the appendix or it may be a physiologic atrophy.

The vermiform appendix may be invaded by tuberculosis or actinomycosis; it may be involved in typhoid fever. These conditions will be considered under the special forms of appendicitis.

Intestinal parasites may find entrance into the appendix and produce an inflammatory reaction. The ordinary round-worms have been repeatedly found. The echinococcus was found in the appendix by Scholler and Birch-Hirschfeld. Still, in two hundred autopsies in children under

twelve years, found the oxyuris in thirty-eight cases, it being present twenty-five times in the appendix.

Hoppe-Seyler reported a case of amebic enteritis in which the amœba coli produced an inflammatory reaction in the appendix.

Neoplasms, either benign or malignant, may be found in the appendix; among the former, polypi, myomata, fibromata, myxomata, and lipomata;* among the latter carcinoma, sarcoma, and endothelioma, either primary or secondary.

In diseases of the lymphoid organs—Hodgkin's disease, for example—the lymphoid follicles of the appendix may be involved, as was shown by Hektoen.

Carcinoma of the appendix is not common if we judge from the post-mortem

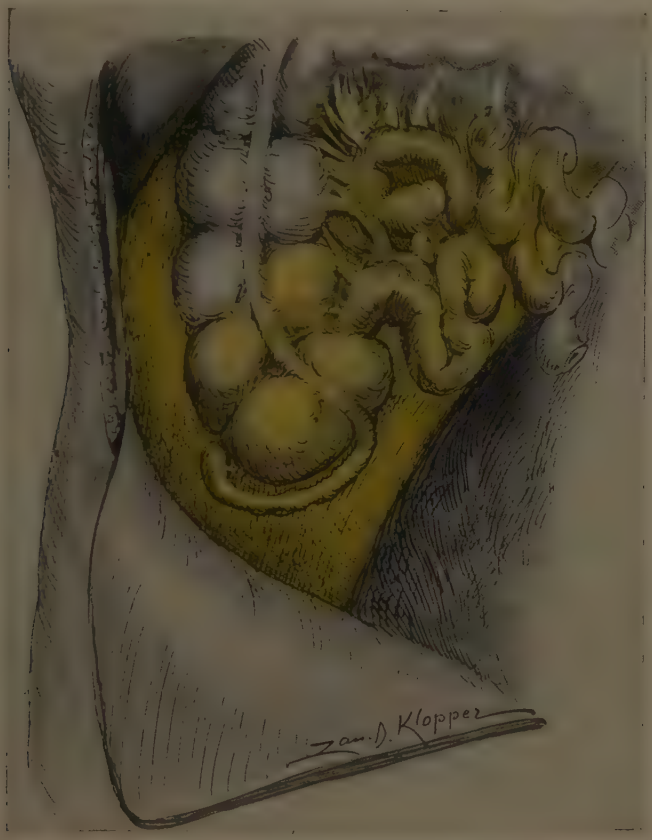


FIG. 417.—SHOWING FIBRINO-PURULENT PERITONITIS LOCALIZED.

records of various large institutions. It is no doubt often overlooked on the operating as well as on the post-mortem table, since the lesions are usually of small size. Maydl, in an analysis of 20,480 autopsies performed at the Vienna General Hospital from 1870 to 1881, found only one case of carcinoma of the appendix among one hundred cases of carcinoma of the intestinal tract. In 20,358 autopsies analyzed by Nothnagel in the interval from 1882 to 1893, there was one case of carcinoma of the appendix among two hundred and forty-three cases of carcinoma of the intestinal tract. Leichtenstern's clinical and post-mortem records show three cases among seven hundred and seventy.

* Benign tumors are not common. Deaver found two cases of fibromyomata. In one case the patient had fibromyomata of the uterus.

At present there are on record about forty cases of primary carcinomata of the appendix. Strangely enough, all were reported within the last ten years, which suggests the probability of more extensive and more careful examination of all appendices removed recently. Rolleston and Jones[14] collected thirty-seven cases of primary carcinoma. The youngest patient was twelve (Letulle and Weinberg), the oldest were sixty-six and eighty-one (Kelly, Elting), the average being 30.6 years.

"Further, the age-incidence varies in the different kinds of carcinomata of the vermiform appendix, being fifty-two years in the columnar-celled, thirty-two in the transitional forms, twenty-four in the spheroidal-celled, and 25.5 in those merely described as 'carcinoma.'"

Sex.—There is no marked preponderance of either sex.

FIG. 418.—TOPOGRAPHY OF SECONDARY ABSCESS AS IT APPEARS TO THE LEFT OF THE MESOSIGMOID, HAVING ASCENDED FROM THE PELVIS.

This neoplasm has a predilection for the tip or its vicinity. Concretions were present in only three cases, showing that irritation was not an important exciting factor, as is usually the case elsewhere. The coats of the appendix showed inflammatory changes, which suggests the possibility of some relationship between inflammation and malignancy. Carcinoma of the appendix gives no especial symptomatology. The malignancy of the neoplasm is not great, as recurrence was rare in the operated cases reported.

Pre-operative Complications.—Peritonitis.—The pus may escape into the peritoneal cavity and produce an acute peritonitis, the severity

of which depends upon the type of infecting micro-organism and its degree of virulence. In many cases, however, the abscess is limited to the periappendical structures by the protecting adhesions of the omentum and intestine which surround and wall off the abscess. In occasional cases the infection may produce a progressive fibrinopurulent peritonitis, as described by Mikulicz. (See Fig. 417.) The circumscribed abscesses of the pelvis are usually extensions of the suppurative process from the iliac fossa into the pelvis. They may extend across the pelvis and up into the left iliac fossa, to bear the same relation to the left anterior superior iliac spine that the appendical abscess bears to the right. The

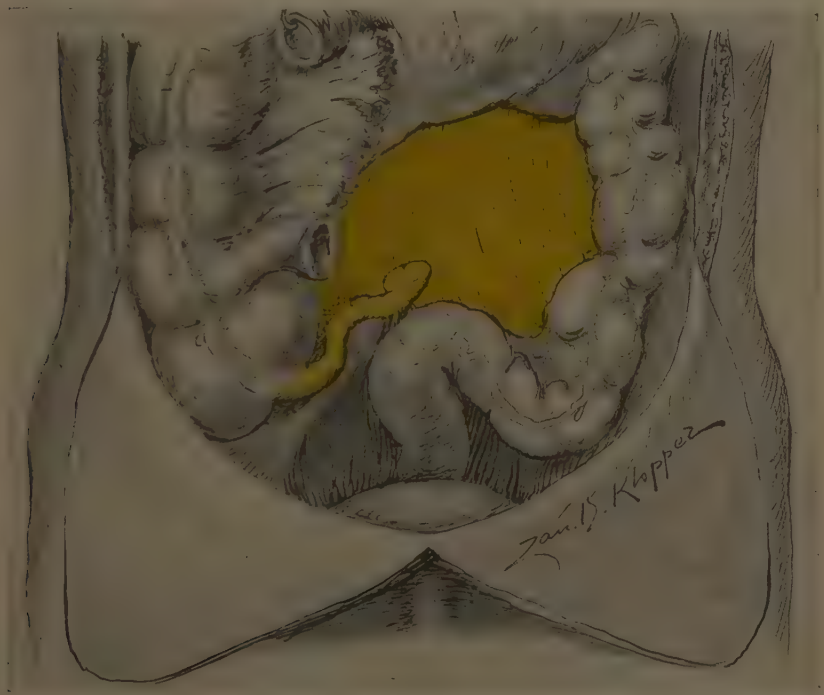


Fig. 419.—Showing the Secondary Abscess between the Sigmoid and the Great Mesentery.

pus may be to the outer side of the sigmoid and can be attacked extraperitoneally. (See Fig. 418.) More frequently, however, it is to the median side, between the great mesentery and the mesosigmoid, and if an attempt be made to open by the extraperitoneal route from the iliac fossa, the sigmoid will be opened. (See Fig. 419.) The best means of opening this is through the left rectus muscle, just to the median side of the linea semilunaris, as the pus will be found to the median side of the sigmoid, and often just beneath the abdominal wall, exactly as it is in the following condition, in which the pus may burrow along the under surface of the great mesentery and accumulate about the lower pole of the left kidney. This abscess should be opened as the preceding, or,

rarely, from behind. Occasionally an abscess forms behind the caput coli and ascending colon (see Fig. 420) and ruptures or is opened through the right loin. Usually the infiltration is very great for the small quantity of pus present, the rule with colon bacillus infections of cellular tissue.

Subphrenic and Hepatic Abscess.—The subphrenic region may become infected (see Fig. 420) secondarily to appendicitis, either through the lymphatics, which is rare, or by continuation of the infective process along the outer side of the colon. Maydl collected one hundred and seventy-nine cases of subphrenic abscess; twenty-three were secondary to appendicitis; Lang found twenty cases secondary to appendicitis among one hundred and seventy-six; Weber, nine cases among six hundred cases of appendicitis operated upon by Sonnenburg. Three hundred and fifty of these had periappendical abscesses.

FIG. 420.—ABSCESS ASCENDING TO THE RIGHT OF THE COLON AND EXTENDING UPWARD INTO THE SUBPHRENIC SPACE.

The liver may be secondarily infected by septic material transmitted to it by the portal vein. The portal vein was thrombosed in ten cases out of eighteen hundred and ninety autopsies at the Boston City Hospital. Bärensprung found among one hundred and eight liver abscesses in a series of seventy-three hundred and twenty-six autopsies performed in Berlin from 1859 to 1873, that eight were of appendical origin. A direct transmission of septic material from the surface into the parenchyma along the lymphatics may take place in a small zone on the right lobe

just to the right of the attachment of the gall-bladder, where a lymphatic stream leads from Glisson's capsule into the parenchyma.

Pylephlebitis is not an uncommon occurrence in late or unoperated cases of appendicitis. In the years 1905 and 1906 we had three such cases in our practice. The infection travels in the ileocecal vein to the portal; here multiple thrombi and abscesses form, the infection extends to the spleen and liver; multiple foci of suppuration appear in both. Metastatic abscesses appear in the lungs, kidneys, etc. All of these cases have recurrent chills and fever, tympany, often diarrhea, night-sweats, emaciation, etc., and terminate fatally. Pylephlebitis occurs much more frequently than is generally believed.

Pleuritis.—The pleura may be infected by extension along the lymphatics or infection may result from a pulmonary infarct. It may also be the result of direct perforation of a subphrenic abscess. An appendical abscess may extend upward behind the liver and penetrate into the pleural cavity.

Vascular Complications.—The arteries or veins may become infected from the appendix. Its proximity to the iliac veins may produce a phlebitis and thrombosis of these vessels, resulting in septic embolism and metastatic abscesses in the general circulation. The iliac artery or vein may become eroded and perforate, leading to severe or even fatal hemorrhage, but this is a rather rare complication. This vessel may be closed by thrombosis, leading to gangrene of the extremity.

The gall-bladder is frequently secondarily infected by a pathologic appendix: first, by direct adhesion of the infected appendix to it; and, second, through the portal circulation. We believe that appendicitis is second only to typhoid fever as an etiologic factor in cholelithiasis. In Ochsner's experience 35 per cent. of the cases of gall-stones had previously suffered from appendicitis. The kidneys and spleen may become secondarily involved by metastasis.

Hematemesis is a rare complication. It is due to a thrombosis of the gastric portion of the portal vein. Intestinal hemorrhage is more frequently observed than hematemesis and is due to the same cause. Jaundice is occasionally noted, either as the result of general toxemia, septic hepatitis, pylephlebitis, or obstruction of the common duct by adhesions from a primarily inflamed appendix.

Cystitis or pericystitis is the result of inflammation of an appendix situated in the pelvis on or near the bladder.

Retroperitoneal infections take place in three different ways: first, by direct communication of infection from the appendix into the cellular tissue; second, by extension of infection through the mesoappendix to the retrocecal tissues; and third, by the lymphatic route. Infection of the retrocecal cellular tissue is a dangerous complication and in virulent cases often leads to extensive gangrene and death. Hence early drainage has no advantage, as the infiltration is diffuse and sacculated pus formation does not occur. If the pus is virulent, the termination through acute intense sapremia is fatal, acting very much like the virulent postpartum infections of the pelvic cellular tissue. At present we fear this type of disease more than we do general infection of the peritoneum.

Severe cases of appendicitis may give metastatic infections in distant organs.

Classification.—We will follow the writer's classification published in the "Journal of the American Medical Association" in 1894, which is accepted by Ochsner as a basis of his description of appendicitis in his able work, "A Hand-book of Appendicitis."

1. Simple catarrhal appendicitis, accompanying a catarrhal enteritis and without especial symptoms, except slight tenderness.
2. Ulceration of mucous membrane without perforation.
   (*a*) Pressure atrophy or ulceration from fecal concretion.
   (*b*) Ulceration with purulent accumulation.
   (*c*) Typhoid ulcer.
   (*d*) Tuberculous ulcer.
   (*e*) Actinomycotic ulcer.
3. Ulceration with perforation.
4. Gangrene of mucous membrane, dependent upon mechanic compression by foreign bodies, by accumulated fluid, or by infection of the wall.
   (*a*) Local.
   (*b*) General.
5. Gangrene of appendix complete, by compression of base by foreign body, by infection of the wall, or by torsion.
   (*a*) With perforation.
   (*b*) Without perforation.
6. Infection of peritoneal cavity.
   (*a*) Without perforation, local or general.
   (*b*) With perforation, local or general.
7. Peritonitis.
   (*a*) Local peritonitis without limiting adhesions.
   (*b*) Circumscribed abscess.
   (*c*) General diffuse peritonitis without limiting adhesions.

Symptomatology.—The symptoms, in the order of their occurrence, may be mentioned as: First, pain in the abdomen, sudden and severe, primarily referred to the epigastrium, followed by (second) nausea or vomiting, most commonly between three and four hours after the onset of pain. Third, general abdominal sensitiveness, most marked on the right side, or more particularly over the appendix. Fourth, elevation of temperature, beginning from two to twenty-four hours after the onset of pain. In severe cases the temperature reaches 102° to 103° between eight and twelve hours after the initial pain. Fifth, leukocytosis. The symptoms occur almost without exception in the above order, and *when that order varies I always question the diagnosis.* If the nausea and vomiting or temperature precede the pain, I feel certain that the case is not one of appendicitis. Where the temperature alone precedes the pain for a day or even two or three, then I am always fearful that it is typhoid fever with a typhoid ulcer in the appendix. I had nine cases of this class; the first three were operated and typhoid ulcers were found in the appendix; the last six were not operated; all went through classic typhoid courses after the appendical manifestations, and all recovered. Where sensitiveness has been present for a number of days, and particularly where it is low in the pelvis, I have found the focus other than appendical—that is, due to infection of the tube, tuberculous peritonitis, etc.

Pain is a constant and uniform symptom, usually colicky in character

although patients vary in their expressions of its severity. In not a single case is it absent as an initial symptom. It usually reaches its acme of intensity about four hours after its onset and subsides gradually in the majority of cases. When it ceases suddenly, within the first thirty-six hours, the subsidence is due either to liberation of the infective material into the caput coli, rupture, or complete gangrene. Under these conditions the pus tension is relieved and the absorption diminishes or stops. With the cessation of pain in these cases comes the diminution or cessation of absorption, *but not necessarily a diminution or cessation of danger*, as is so commonly though erroneously interpreted, and often with fatal result. The primary pain with the *free* appendix is always referred to the epigastric surface of the abdomen. When it is embedded on the caput coli or fixed to the parietal peritoneum or adherent in the pelvis, the pain is then announced in the local position of the appendix.

The secondary pain, after the first thirty-six hours, is usually not colicky, but of the typical inflammatory type and due to periappendical involvements. Severe pain after the primary subsidence is always a signal of great danger, as it announces a beginning peritonitis from perforation.

According to Mansell Moullin,[10] the pain over the appendical region is due to active peristalsis of the cecum or appendix pulling upon the peritoneal attachment to the abdominal wall. If the inflammatory process progresses and involves the muscular coat, peristalsis ceases, and with it the localized pain or colic, but the sensitiveness remains.

The pain in appendicitis may be referred to the various quadrants of the abdomen, depending upon the change in position of the appendix, either from a congenital malposition or from an erratic attachment—a sequence of inflammation. The pain is often referred to the gall-bladder region, to the epigastrium, the umbilicus, rectum, or chest. In the latter case it may be due to a concomitant pleuritis or it may be reflex in origin. In one case there was no tenderness in the region of the appendix, although the history was highly suggestive of appendicitis. The patient was very sensitive on perpendicular percussion below the right costal arch, and a possibility of gall-bladder trouble was considered. The operation revealed a short ascending colon with the appendix adherent to the under surface of the liver.

The primary nausea and vomiting is reflex, due to overdistention of the appendix from the accumulating products of the infection, and is the same type of nausea and vomiting that we have with stone suddenly impacted in the neck of the bladder or suddenly passed into the ureter. There are usually only a few efforts at emesis and the nausea then passes away. The *secondary nausea* and often *persistent vomiting* are due to the periappendicular involvement,—that is, infection of the peritoneum,—and the vomiting is of the same character and often has the same persistence as vomiting from perforation of the tube, intestine, or stomach, into the peritoneum. In extensive peritoneal infections the vomiting continues to the fatal termination, increasing in frequency as time advances and absorption increases.

The abdominal sensitiveness is at first diffuse, although the abdominal wall is not particularly rigid. When the appendix becomes fully distended and tense, it will not tolerate pressure and is protected by a marked rigidity of the abdominal muscles. As soon as the acute tension subsides the general sensitiveness disappears. It becomes circumscribed in the area of the appendix, whether it be McBurney's point, in the subhepatic space, or in the pelvis. If the sensitiveness has been once circumscribed to a small area and increases suddenly, preceded by pain and secondary nausea and vomiting, it strongly indicates a perforation of the circumscribed adhesions and an infection of the general peritoneum. In endeavoring to palpate the appendix, after the first twenty-four hours, the greatest care and caution should be exercised; severe pressure is likely to produce separation of friable adhesions that are of life-saving importance.

Temperature is not absent in a single acute infective case in its *early stage;* that is, in the first thirty-six hours after the onset of the symptoms. In acute obstruction of the neck of the appendix, with mild infection, it appears later. In the calcular obstructions it is often not manifest until about the twentieth to the twenty-fourth hour after the beginning of pain. I will not operate on a case where I am confident that no temperature has been present in the first thirty-six hours of the disease. I came very near making an unnecessary laparotomy in a case of this character. The patient had typical acute onset of pain, nausea and vomiting, local sensitiveness, and tumor; so sensitive was the tumor that manipulation was impossible. The patient was a doctor's daughter. Her father insisted that there had been no temperature at any time, but I felt that attention had not been close enough to warrant this statement. After she was anesthetized and on the table for operation, with manipulation the tumor was made to disappear under the costal arch, proving it to be an acutely displaced kidney; no operation. When the patient recovered from the anesthetic, she informed us that in play at a picnic two days previously she was rolled across the edge of a board fence, the pressure being from behind forward, just below the last rib. It caused her severe pain in her side, which continued from that time. This produced an acute displacement of the kidney.

The temperature may all subside within twenty-four hours after the onset, and if it subsides suddenly one should be fearful that the cause of its subsidence is a gangrene of the mucosa, with failure of further absorption and therefore an intermission of temperature. When it subsides gradually, from thirty-six to fifty-two hours after the onset, it is due to a cessation of tension from intracecal drainage, to rupture of the appendix into the mesoappendix, or to circumscribed adhesions around the appendix. The temperature here, as in other places, must be recognized, not as a manifestation of pus, but as a manifestation of absorption of the products of infection.

A remission of temperature of one, two, or three degrees with subsequent gradual elevation means an infection of a new area of tissue.

The temperature may go below 99° and remain there after the initial elevation, and still a large quantity of pus be present in the peritoneum.

Secondary elevation of temperature should always be noted with apprehension, as it indicates a fresh invasion of tissue, a thrombophlebitis, a peritonitis, or cellular infiltration. These elevations are indications for immediate operation, usually drainage. Under these circumstances no extensive laceration of tissue or separation of adhesions should be attempted for the purpose of making a complete operation. The focus of pus should be drained and, as a rule, nothing more done.

Leukocytosis.—As a matter of our routine, which is indispensable in thorough hospital work, the blood-count is made before and after the operation; while I do not underestimate the relative value of leukocytic reaction in inflammations of the appendix, I consider it only corroborative.

The rôle of the polynuclear cells, we feel, is excellently estimated by Hans Albrecht.[10a] The percentage of polynuclear cells is an indication of the severity of the infection, but not the degree of destruction; a high percentage does not denote a bad prognosis, so long as the absolute number of white cells is correspondingly high. A fall in the absolute number of polynuclears with a coincident decrease of the total percentage of leukocytes shows a decline in the infection; a sudden fall in the absolute number of polynuclears with a very small decline or perhaps a rise in the percentage of white cells is of unfavorable prognostic import, since it shows that the production of the polynuclears does not keep pace with their consumption, indicating an exhaustion of the blood-forming elements for defensive purposes. A very unfavorable sign is a sudden fall in the total number of leukocytes. Beginning recovery is manifested by a rise in the absolute number of mononuclear and eosinophilic leukocytes, even to or above the normal.

We have never found leukopenia with acute infections of the appendix.

Pulse.—The character of the pulse has little value in the differential diagnosis of appendicitis. In children when there is rapid absorption the pulse-rate is very high. In the later stages of peritonitis, when it becomes compressible, rapid, and feeble, it is a fair index of the degree of intoxication and a guide to the prognosis rather than to the extent of the inflamed area.

Feeble capillary circulation and cyanosis are of grave prognostic significance.

Tumor.—In the very early hours of appendicitis, while the inflammatory process is still confined within the appendix, an examination of the abdomen reveals an apparent tumor. One feels convinced that the appendix rests close to the abdominal wall. The impression of tumor is due to the spasmodic contraction of the muscle-fibers directly over the appendix. When the patient is under the anesthetic the tumor entirely disappears, and, indeed, the appendix may be in the retrocecal position and many inches from the abdominal wall. So frequent is this deception that I feel it should be constantly borne in mind. Bimanual comparative compression of the right and left iliac fossæ readily shows the great

resistance to compression on the right side, with little if any on the left. In the subacute cases the enlarged, swollen, and distended appendix can be frequently outlined by careful examination. As the periappendical tissues become involved and the quantity of infective material increases, the tumor becomes more pronounced and often attains considerable size. This is usually located in the right iliac fossa, but its absence from that position, with a clinical history indicating an appendicitis, must not be construed as meaning that the tumor is not present; it will be found in the loin or low in the pelvis.

Fluctuation is present only when there is a large circumscribed abscess in the later stages of the disease. In the early stages the absence of

FIG. 421.—GANGRENE OF MUCOSA WITH EARLY PERFORATION, WITHOUT CALCULUS.

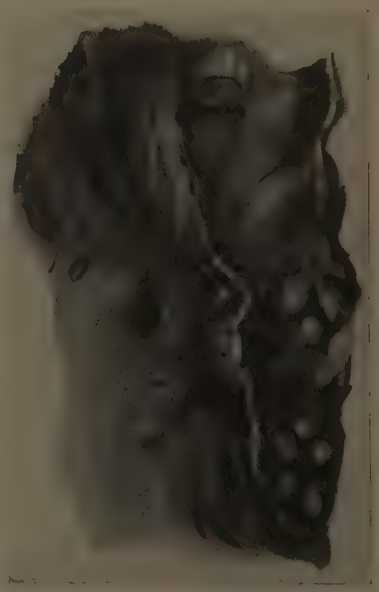


FIG. 422.—COMPLETE GANGRENE OF THE WALL WITH GANGRENE OF THE MESENTERIOLUM.

peristalsis in the appendical region is of value in indicating the nature of the process. A careful examination with the stethoscope reveals a "still" area for many inches around the appendix.

The size of the tumor bears little relation to the quantity of pus.

The greatest difficulty is experienced in making a differential diagnosis between appendicitis and acute catarrhal conditions of the caput coli, or acute retention in the caput coli, especially associated with the intestinal type of la grippe. Here we have the pain, nausea, and vomiting, the local sensitiveness, the elevation of temperature, and leukocytosis all combined, and so closely does the attack resemble appendicitis that in two cases we have erred in the diagnosis. In both there were evidences of previous attacks of appendicitis, with adhesions of the appendix,

but in neither was there manifestation of an acute process in the appendix. Nor have our errors taught us a means of preventing their recurrence. We believe we have avoided many errors in diagnosis by the careful analysis of the clinical history and the stress which we placed on the *order* of occurrence of symptoms, namely, pain, nausea and vomiting, local sensitiveness, elevation of temperature, and leukocytosis. A deviation from this order causes us to seriously doubt the diagnosis of appendicitis.

In addition to the symptoms enumerated, a few other facts must be added. When the appendix is retrocecal or retrocolic, when it is in the

FIG. 423.—SHOWING EARLY COMPLETE GANGRENE OF THE ENTIRE WALL WITHOUT STONE.

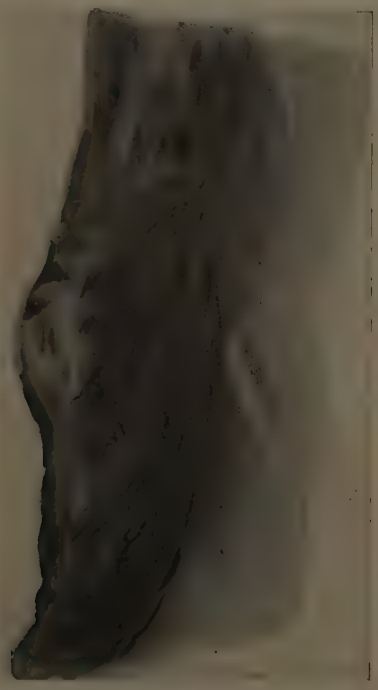


FIG. 424.—SHOWING EARLY COMPLETE GANGRENE OF THE ENTIRE WALL WITHOUT STONE.

pelvis, and particularly in children, is rectal examination of great diagnostic value.

In the severe cases in which the pathologic process advances toward destruction, the patient assumes the *facies abdominalis*, which is a positive index as to the severity. Frequent urination is not an uncommon symptom and urinary retention is not infrequently present. In atypical cases, especially when one fails to make a careful microscopic urinalysis, error in diagnosis in favor of a genito-urinary disease is not uncommon. This symptom is manifest when the appendix is situated in the pelvis, the bladder being directly irritated by the inflamed appendix or by the inflamed tissues surrounding it. Occasionally the frequency in micturi-

tion is due to some sympathetic disturbance. In the chronic form of appendicitis constipation is a frequent occurrence.

Clinical Course.—The clinical course is fairly uniform. In the acute infectious cases without calculus the mucosa becomes infiltrated and edematous within an hour or two after its infection (Fig. 421). The edema and infiltration increase rapidly and the compression of the inelastic coats of the appendix with the assistance of the biotic and toxic effects of the pathogenic flora produce a rapid gangrene of the mucosa, submucosa (see Fig. 422), and occasionally the entire thickness of the wall, with now and then complete gangrene of the appendix, and extension of gangrene into the mesentery, so that in virulent infections a perforation of the appendical wall, on the average, takes place in from twenty-six to forty hours. (See Figs. 423 and 424.) Infection with the presence of a foreign body (fecal concretion) is usually associated with only a small area of gangrene, and that at the point of pressure of the calculus; local necrosis or gangrene with perforation and leakage (see Fig. 426); perforation in these cases takes place some hours earlier than in the infections without a foreign body (Figs. 409, 427). Occasionally pressure ulceration and perforation of the appendix take place at the seat of a coprolith without an acute infection. In this last class of cases the first announcement of the trouble is made by the initial symptoms of perforative peritonitis. These represent about 1 per cent. of all of the acute cases. It is a dangerous type for the patient, as the initial symptoms are attributed to a beginning appendicitis, when in reality they are due to a beginning *perforative* peritonitis. In these cases there is *early* and *great* leukocytosis.

FIG. 425.—APPENDIX REMOVED FORTY HOURS AFTER ONSET OF PAIN.

Gangrene of mucosa, complete discoloration of mucosa beginning.

In the steptococcus infections the mesoappendix and neighboring tissues are more seriously involved and the area of gangrene is less than with the colon bacillus or the staphylococcus types. The pain is most severe in the first six to fourteen hours; it becomes less as the necrosis advances; the temperature is highest from the sixteenth to the thirtieth hour, preceding the completion of the gangrenous process. If the gangrene continues to advance, the temperature remains up; if it becomes stationary, the temperature declines. In one case of complete gangrene of the appendix the temperature was 104° nineteen hours after the onset of pain; it was 99.2° seven hours later, at the time of operation. The appendix was gangrenous throughout its entire wall to its junction with the cecum. (See Fig. 424.) It was a black, shining mass without an adhesion and slipped into the abdominal incision. The necrosis was so

FIG. 426.—LOCAL NECROSIS AND GANGRENE AT POINT OF FOREIGN BODY WITH PERFORATION.

rapid and complete in this case that there was no effort made by the wall of the appendix to fix itself to the neighboring tissues. We regard with alarm a sudden drop in the temperature and interpret it as meaning, first, a cessation of absorption, due, most commonly, to perforation, with diminished pus pressure; second in frequency, to the escape of the contents into the intestine; third, to gangrene; fourth, to circumscribing tissue infiltration with diminished absorption (local immunity); and, fifth, diminution of the virulence of the flora.

FIG. 427.—LOCAL NECROSIS, GANGRENE, AND PERFORATION AT POINT OF FOREIGN BODY IN DISTAL PORTION OF APPENDIX.

After fifty hours the clinical picture changes to that of infections of the periappendical regions (perityphlitis or paratyphlitis). If the perforation takes place into the mesoappendix, or under circumscribing adhesions, the clinical presentations are those of a limited infection, while if into the free peritoneal cavity the symptoms of a more or less diffuse peritonitis manifest themselves, depending upon the types of infection and the degree of involvement.

After a circumscribed abscess has formed, the temperature, pulse-rate, and pain subside to a considerable degree; indeed, the temperature may approximate normal as the infiltration in the abscess wall becomes more and more pronounced and absorption proportionately diminishes. If the rupture be into the post-peritoneal cellular tissue, there is rapid rise of temperature from the absorption. If it be into the free peritoneal cavity, the rule is, first, a primary drop of temperature as the pus is relieved of tension and the peritoneal endothelium has not yet been abraded, and therefore does not allow rapid absorption. In a staphylococcus infection of the milder type the peritoneum is first covered with an exudate, which may go on increasing in thickness to the formation of a membrane resembling the diphtheritic type. This lessens the immediate absorption and protects the patient against an overdose of the bacteria and septic products. It paralyzes peristalsis and produces coprostasis, but in a short time this plaque is thrown off, and carries with it the endothelial covering, leaving a distinctly abraded or blistered surface from which there is rapid absorption, and a sudden collapse of the patient, frequent bowel discharges, anxious expression, and, shortly, death. This sudden change takes place between the evening of the fourth and the morning of the sixth day. If the primary infection be of the streptococcus type, and rupture into the peritoneum, there is rapid blistering of the peritoneum and, within a few hours, symptoms of intense intoxication, high pulse, anxious expression, talkative delirium, hyperesthesia, tympany, and all the manifestations of severe and acute streptococcus intoxication.

The action of the colon bacillus may be said to be midway between these two pictures. At times it produces but slight irritation, moderate elevation of temperature, considerable seropurulent exudate, and a gradually increasing disturbance of the endothelial covering. The advancement is so slow that the tendency is to circumscription of the process by peritoneal adhesions. Under certain conditions, which we little understand, the colon bacillus may have a powerfully irritating effect on the peritoneum, produce rapid destruction of its lining cells, and expose its lymphatics for rapid absorption. Indeed, its virulence may be so great as to produce gangrene of the peritoneum and even of the entire intestinal wall. This is fortunately rare, but is an extremely fatal type of the action of this bacillus. Perforation and advancement through the wall of the appendix with colon bacillus infection are slow and give time for the staphylococcus albus to multiply in large quantities in the seropurulent fluid in the peritoneum and induce an infiltration of the peritoneum, thus producing a local immunity. The degree of this is controlled by the opsonins. We believe the infiltration of the tissues produces a local immunity or a retardation of absorption in the peritoneum, just as it does around infections in cellular tissue, where without infiltration the phagocytes would soon be overwhelmed and the leukopoietic power exhausted. Sometimes a gas bacillus is associated with the colon bacillus and the tissue becomes emphysematous. Usually there is not a high temperature in this class of cases, but great physical depres-

sion, lowered arterial tension, sunken eyes, somnolence, and finally low muttering delirium, differing entirely from the clinical picture of the streptococcus intoxication.

M. Lannelongue endeavored to determine the degree of toxicity in an individual case by the *urotoxic coefficient* per kilogram of body-weight necessary to produce death in rabbits. This means of determination has not become a practical one, and its value as a general procedure therefore is not definitely determined, although Lannelongue considered it a positive aid to prognosis.

The quantity of pus found in the peritoneal cavity in the dry staphylococcus type is usually small. It may be large, and then it is of a sero-purulent character. With the virulent streptococcus type there is little, if any, free pus, but the peritoneum has that peculiar dry, granulating, blistered appearance which was so frequently seen in the post-partum sepsis of the pre-antiseptic period. The colon bacillus produces pus with an offensive odor, usually considerable in quantity and thick and creamy in character. The intestines are agglutinated and many times separate pockets are formed. The elevation of temperature, the tympany, and the collapse are usually slower in appearing with the colon bacillus than with either of the other types of infection. Collapse is not a sign of perforation, but a manifestation of the absorption of the bacteria and their products by an abraded or blistered peritoneum. It will appear rapidly or slowly after perforation, depending on the virulence of the infection and the rapidity with which the endothelium of the peritoneum is destroyed. This has been one of the most difficult lessons for the profession in general to appreciate. For years we believed that collapse was an immediate manifestation of perforation; we must now recognize that it is a symptom of septic intoxication, and always a late symptom, as far as the clinical course is concerned.

The closest attention should be paid to the relation between the symptoms and clinical course and the pathologic findings, so that we may better anticipate the intra-abdominal changes by the symptoms and physical signs, or at least that we may know when and under what conditions pathologic changes are not announced by appreciable symptoms, and thus avoid fatalities and surprises by a proper interpretation of the presence, order, or absence of symptoms.

We must state, however, that we are just beginning to appreciate the great disturbances that can be produced in the gastro-intestinal tract and in the general metabolism, and the distressing and complex train of symptoms which result from the minor or chronic appendical lesions. We must operate much more frequently in the future for their relief than we have in the past, as we are learning from clinical experience that the disturbances produced by them are out of proportion to the logical deductions that could be made from the extent of pathologic conditions. The completeness of cures by operations on this class of cases is one of the most gratifying in the entire field of abdominal surgery.

Dyspeptic symptoms are very frequently the prominent feature of chronic appendicitis, and more than one patient is treated for a gastric affection and even operated for gastric ulcer.

In women dysmenorrhea is a very common symptom of chronic appendicitis, and in a great number of cases it can be distinctly traced to the first appendical attack.

Berardimone[11] calls attention to an early symptom in appendicitis which he considers of considerable diagnostic value. He observed in five cases out of six the sudden and distinct enlargement of a single lymph-node above Poupart's ligament on the right side, near the external ring. He attributes this to the resultant peritoneal infiltration, the sequence of the appendicitis, which obstructs the return flow of lymph.

Typhoid Appendicitis.—Typhoid bacilli which invade lymphoid structures of the intestine do not overlook the lymphoid follicles of the appendix, and so it is that frequently the appendix is the seat of typhoid infection, either as an extension from the ileum or as a concomitant infection.

In what is called a "typhoid appendicitis" the cases must be clearly distinguished one from another and carefully grouped.

1. A patient may have a typhoid invasion of his appendix during the activity of typhoid fever.

2. A non-typhoid infection may take place in the appendix during the course of typhoid.

3. A recurrent attack of a previously non-typhoid appendicitis may occur during typhoid.

4. Typhoid fever may begin at the end of convalescence from appendicitis.

All the cardinal symptoms of acute appendicitis may be present in typhoid, but their order is disarranged; this interchange should always make us doubtful of the diagnosis of typical appendicitis. Pain in McBurney's point is frequently present in typhoid, and is due, according to Curschmann, to an invasion of the parietal peritoneum. The pain, however, is never colicky. Nausea and vomiting, abdominal tenderness, and elevation of temperature are also present.

The existence of a typhoid epidemic, the leukopenia, Widal's reaction, Ehrlich's diazo reaction, and the presence of typhoid bacilli in blood-cultures will make a differential diagnosis if the surgeon, in all doubtful cases, is careful enough to resort to and exhaust all laboratory means at his disposal. M. H. Richardson considers a soft abdomen, even in the presence of pain and tenderness, with a high temperature, as pathognomonic of typhoid fever. This is not in consonance with our observations.

Among one hundred and nineteen post-mortems on typhoid patients at the Johns Hopkins and Boston City Hospitals, nineteen showed involvement of the appendix.

Treatment.—The treatment of typhoid ulcers of the appendix should be that of typhoid fever in general, and not surgical except when they perforate.

Actinomycosis.—The appendix is occasionally the seat of a primary actinomycosis. Since I published, in 1885, the first case of "actinomycosis hominis"[12] recognized in this country, there has been a progressive and rapidly increasing number of cases reported in the literature; only a small percentage, however,

affected the appendix. The disease is contracted through the ingestion of grain, the chewing of straw, eating partially cooked meat, or by direct contact with actinomycotic cattle. Similar to tuberculosis, the disease favors the cecal zone of the intestinal tract, but in contrast with tuberculosis it prefers the appendix to the cecum. Abdominal actinomycosis may originate either from the intestinal tract, from the thorax through the diaphragm, or from the abdominal parietes. Hinglais found the appendix involved sixty times in one hundred cases of abdominal actinomycosis. The disease is difficult to diagnose; its symptomatology is not of the stormy type usually associated with acute appendicitis; there is an ache rather than a pain; the infiltration in the iliac fossa and enlargement of the mass is slow and the infiltration is exceptionally hard, indeed ligneous. This should lead one to suspect this disease or a malignant growth. The process frequently tends to perforate through the abdominal wall, and when it does the yellow sulphur-like granules in the pus and along the sinus in the abdominal wall are pathognomonic. The actinomycotic process does not suppurate unless mixed infection takes place. The disease may spread through the mucous membrane of the intestine, it may invade the abdominal fascia, infiltrate the abdominal wall, or spread in the line of least resistance in the direction of the kidney or pelvis, preferring the fatty tracts for its route. It may extend up to the liver, beneath the diaphragm, or along the mesentery to the opposite side of the abdomen. Metastatic foci may appear in different portions of the body through blood transmission. It never travels *through* the lymphatic chains, but often *along* them in the loose fat. It always has a chronic course. It requires surgical treatment when in a circumscribed zone, as the appendix and caput coli, and should then be completely excised. After it has become extensive efforts at excision are futile. It should be treated with sulphate of copper in the maximum dose, after the plan of Bevan,* or with iodid of potassium. These lines of medical treatment give fairly good results.

Tuberculosis.—Frequency.—In five hundred necropsies made by Letulle he found the disease in the appendix in one hundred and forty-four; in 91.6 per cent. there was tuberculosis in the cecum. These necropsies, however, were made on subjects dying of tuberculosis, and do not at all represent the relative percentage in surgical cases. By taking the combined statistics of various operators, it is found that of one hundred cases of appendicitis not more than one or two are tuberculous.

Tuberculosis of the appendix is either primary or secondary. Tuberculosis secondary to that of the genitalia is common. In four cases out of seven in which the appendix was adherent to tuberculous adnexa it was also tuberculous. It is more common in men, and between the ages of twenty and forty. The bacilli may reach the appendix in four different ways: by way of the bowel, the peritoneum, the lymphatics, or the blood. The first is the most frequent.

Pathology.—Tuberculosis affects the appendix in three distinct forms: (*a*) ulcerative, (*b*) hyperplastic, and (*c*) peritoneal tubercles. The first is the most common. It invades most frequently the tip, next the base, and least often the middle; in other words, the points of fecal stasis are those most frequently infected. It may remain confined within the walls of the appendix for months or even years, resembling lupus in its progress, either slow or rapid destruction with repair in one zone while papillary ulceration or destruction is advancing in another. It rarely perforates into the free peritoneal cavity. Occasionally it forms periappendical abscesses, which usually open into the bowel. Large pericecal abscesses may form and resemble the psoas abscesses of spinal caries and may burrow and open in a similar manner in Scarpa's triangle (Fig. 428) or on the anterior abdominal wall. The drainage of the tuberculous débris

*Journal of the American Medical Association, Nov. 11, 1905.

of the appendix into the cecum not infrequently infects the latter. The hyperplastic variety produces great infiltration of the wall and enlargement of the appendix to many times its normal size. It may be free or fixed by peri-appendicular adhesions. From its size, the density of its wall, and its gross appearance it is not infrequently diagnosed as malignant disease. The microscope reveals the error of such interpretation.

The peritoneum of the appendix may be infected in two ways: (*a*) by transmission of the tubercle bacilli from its ulcerated mucosa through the lymph-spaces to its peritoneum. The white and gray tubercles may be recognized on and beneath its serosa or they may stud the peritoneum of the cecum and ileum in its neighborhood. In acute invasions the spots are bright red, with radiating vessels from each of the millet-sized zones of infection. (*b*) The peritoneum of the appendix is not infrequently secondarily infected from tuberculosis of the tube and neighboring viscera, even without being adherent to them.

FIG. 428.—TUBERCULOUS ABSCESS BURROWING UNDER POUPART'S LIGAMENT INTO SCARPA'S TRIANGLE.

The symptomatology takes on three distinct forms, depending upon the activity of the process, in order of frequency as follows: (*a*) chronic, (*b*) acute, and (*c*) latent. There is nothing pathognomonic of tuberculosis in the symptoms. If tuberculosis is suspected, the ocular or hypodermic tests of tuberculin immediately indicate its presence somewhere, presumably in the appendix; the latter not infrequently produces symptoms of rather an active appendicitis.

The *chronic* variety of tuberculous appendicitis is by far the most

common. Pain is less severe, vomiting less frequent, temperature less elevated (except in subjects already tuberculous), than in any of the pus infection varieties. In the latter event the appendical tuberculous exacerbation does not modify the thermic curve. In this variety also diarrhea is so frequent (twenty-four out of sixty-six cases) that it is of special diagnostic value.

When the abdomen is palpated in some cases nothing whatever can be discovered, even on the most careful examination. In others a small, hard, resisting cord can be felt slipping under the fingers. In still others the lesion is not circumscribed, a diffuse doughiness is found, or an uneven deep induration. In these cases the process is not confined to the appendix, as the peritoneum in the vicinity is also inflamed. The combined pelvic and abdominal examination should never be overlooked in women.

Prognosis and Complications.—Tuberculosis of the appendix may be propagated to the neighboring organs, to the glands, the intestines, the peritoneum, and the omentum. Extension to the tube, ovary, and pelvic peritoneum on the right side has also been noted.

Distant foci of tuberculosis not infrequently renew activity following operation for appendicitis. The operation itself often lights up old foci in the peritoneum. These are not due to the intervention on the appendix *per se*, but to the depletion of the patient, and would result from any equally depressing operation (G. Herisson).

Appendicitis in Children.—The appendix in young children is situated higher than McBurney's point. The size and lumen are larger, as compared with the rest of the alimentary canal, than in adults. The walls, however, are more delicate. The cecal end is funnel-shaped, which permits foreign bodies to enter and escape very readily.

The youngest cases operated are those reported by Blumer and Shaw and by Fenger, the subjects being seven weeks old.

As regards symptomatology and clinical course, there is usually a preceding gastro-intestinal disorder. The onset is rather sudden; the pains are violent and continuous. The clinical picture is alarming; convulsions are common; children frequently complain of pelvic pain, and a rectal examination reveals sensitiveness on the right side. Frequent micturition is rather a common symptom and is probably due to the proximity of the pathologic process to the urinary bladder. The skin covering the appendix is extremely sensitive. A slight pinching of the overlying skin causes extreme pain (Dieulafoy). The omentum comes to the rescue more frequently and earlier in children than in adults. Suppuration is the rule, but general peritonitis is less frequent. The appendix of infants is not so prone to perforation or gangrene.

The differential diagnosis of appendicitis in children is difficult, as the history and symptomatology obtained are always inaccurate. Appendicitis closely resembles the attacks of gastro-intestinal disorders which are so common at that age. Intussusception, particularly in the ileocecal zone, is common among children; it, however, rarely gives an elevation of temperature as an early symptom. In the differential

diagnosis all pathologic conditions mentioned in the adult should be considered. Particular stress must be laid on the intestinal colic.

In pneumonia in children the pain is frequently referred to the abdomen, and when in the right side, to the appendical area; and if the diaphragm is involved in pleurisy, great tympany, fecal stasis, and absence of peristalsis may be present. Trousseau, the great French clinician, always said to his students, "Whenever an infant complains of pain in the abdomen, carefully examine his chest." Inguinal hernia, either strangulated or non-strangulated, may simulate appendicitis. Twisting of the cord of an undescended testicle must also be considered.

Kirmisson and Guimbellot, in their collection of cases of appendicitis in children, reported nine under one year of age, and all died; of twenty-six in the second year of life, seven recovered. All fatal cases were not operated on; the seven cases which recovered were all operated upon. This is a strong example of the clean-cut indication for surgical intervention.

Appendicitis in the Female.—The appendix may be primarily involved and infect the genitalia secondarily or *vice versa*. Deaver thinks that the first is the most common. Gynecologists like Price, however, find the genitalia involved primarily. In our practice the primary focus has been about equally frequent in both. Of one hundred and thirty-two appendical abscesses collected by Rotter in 1890, forty were pelvic, the appendix being situated in the pelvis in twenty-seven cases. Tuberculosis of the genitalia, infected ovarian cysts, infected subserous myomata, and ectopic gestations may infect the appendix secondarily. Malignant conditions and papillomatous cysts of the ovary are not infrequently engrafted upon the peritoneum covering the appendix.

The relationship between appendicitis and diseases of the adnexa in the female is recognized by every gynecologist and surgeon. Krueger, Sonnenburg's assistant, analyzing a number of cases operated upon by his chief, found a simultaneous involvement of the appendix and the adnexa in twenty-one cases. Deaver is of the opinion that a very long appendix coming in close relation to the pelvic organs may infect them. He speaks of a case in which "the right ovary was the seat of an abscess which had evidently been infected by a perforated appendix." "In my experience approximately 30 per cent. of all cases of perforative or gangrenous appendicitis in the female had a secondary involvement of the right ovary and tube" (Ochsner). Ochsner also sees a relationship between appendicitis and the production of ovarian cysts. He has found the appendix involved in a number of cases of ovarian cysts, and while he states that it may be a mere coincidence, he thinks that it may be possible, "if not probable," that a former attack of appendicitis may, through its adhesions to the surface of the ovary, close a Graafian follicle, which subsequently becomes distended by fluid and gives rise to an ovarian cyst. Appendicitis in the female occurring in early childhood or at puberty may so involve the appendages as to surround or embed the tubes and ovaries in extensive adhesions which mechanically obstruct the tubes and predispose the individual in this way to sterility.

A positive diagnosis as to the primary involvement of the appendix or pelvic organs is often difficult, even after opening the abdomen and inspecting the organs. A slightly thickened appendix surrounded by few adhesions may be adherent to enlarged, tortuous pelvic organs, and still the process be primary in the appendix. The greatest difficulty in differential diagnosis exists between tuberculosis of the tube with recurrent explosions, salpingitis with recurrent leakages, and twisted ovarian pedicles. A careful analysis and examination, with association of the symptomatology and physical signs, however, enables one to make a positive diagnosis. The most important condition, though not the most difficult of differentiation, however, is ectopic gestation, especially in the first eight weeks. The incomplete cycle of symptoms of uterine pregnancy, the character of menstruation, the physical signs, the examination of uterine discharges for decidual cells, etc., the periodic colicky pains, the irregularity in the chain of appendical symptoms, and particularly the explosive anemia and the absence of temperature, with the symptoms of intra-abdominal hemorrhage, lead one to a differential diagnosis.

Rupture of a tubal or ovarian abscess gives symptoms very similar to those of rupture of the appendix.

Primary appendicitis in the female should be treated the same as in the male. In secondary appendicitis the median incision should be made so that diseased pelvic organs as well as the appendix may be removed; the floor of the pelvis should then be covered by omentum or sigmoid so as to prevent the possibility of subsequent adhesions.

A number of surgeons advocate the removal of the appendix, irrespective of its condition, whenever the abdomen is opened. Howard Kelly has written to eighty surgeons asking whether or not it is advisable to remove the appendix in every laparotomy. Of the seventy answers, twenty-six were pro and forty-four contra; Kelly is against the removal of the organ as a regular procedure whenever the abdomen is open, and substantiates it with the following arguments:

First, it prolongs the time of operation; it increases the shock and makes the risk of the operation greater.

Second, the unnecessary removal of the appendix may perhaps harm the individual, because the appendix may have a physiologic function of which we are not aware at the present time.

We never remove it except where there are definite pathologic changes or where there is a history of previous attacks. It undoubtedly increases the hazard, as it prolongs proceedings, involves intestinal manipulation and peritoneal exposure, opens the septic intestinal tract, and necessitates an intestinal suture and union, all of which, no matter how skilfully done, carry with them additional risks.

Appendicitis with Pregnancy.—Appendicitis in pregnancy involves the question of a pregnancy uninterrupted; the mortality of the mother from the appendicitis; the mortality of the mother and the child by induced or accidental labor and the influence on the course of the labor and parturient period by it. According to Donohue, 80 per cent. of

the cases occur in the first six months. The course does not vary from the ordinary clinical picture in non-pregnant women. The diagnosis, however, is often overlooked, as both the patient and the physician are accustomed to ascribe all symptoms in the abdomen to disturbances of pregnancy, and also because physical examination is not satisfactory, especially after three months of pregnancy, when the ascending uterus begins to cover the ileocecal region. As leukocytosis is present in pregnancy, it loses its value as an index of the presence or degree of infection in associated appendicitis. The association of the two conditions is serious, as the diagnosis is usually tardy, the operation late, inducing premature labor in the presence of sepsis.

Mundé, in 1894, was the first to operate on a pregnant woman with appendicitis. In 1897 Abrahams collected eleven cases from American literature and added four which he observed. He reported a mortality of 53 per cent. in the mother and practically 100 per cent. in the child. Since that time many cases have been operated. Of thirty-one cases collected by Boije, of Helsingfors, fourteen died; abortion took place in eighteen cases. Heaton reported 78 per cent. abortions.

Marx advises induced labor in acute cases, preceding the abdominal operation. Webster[21] favors this procedure because it allows vaginal drainage, if needed. He does not recommend it in cases of circumscribed abscess, as the contraction of the uterus might rupture the abscess, to which the latter may be adherent.

Appendicitis occasionally occurs soon after labor. The clinical picture of peritonitis of uterine origin greatly resembles that of appendical causation, and a differential diagnosis can only be arrived at by a careful analysis of the colic, the circumscribed *suprapelvic* hypersensitiveness, the absence of induration in the fornices, and often with a distinct history of previous attacks of appendicitis. In the hands of surgeons of experience premature labor should not be induced. If the operation is timely, the appendix should be removed. *If late, the circumscribed abscess should be drained through a small incision and no effort whatever made to remove the appendix.* By this plan abortion will be rare, peritonitis still rarer, and death an uncommon sequence, *in place of its present appalling frequency.* Extensive manipulation of the peritoneum and viscera and prolonged operation are responsible for the miscarriage and abortions, and are never justifiable on the basis that a radical cure may be effected by removing the appendix at one sitting. The appendix may be removed as a secondary operation, after parturition, without hazard to the patient.

Diagnosis.—The diagnosis of acute appendicitis is rarely difficult, as the symptoms occur in such uniform order. The severity of the individual symptoms varies. The order of symptoms is as follows (and the *order* is *all-important* in making a diagnosis): *First*, pain, acute, severe, referred at first usually to the epigastrium, and continues there as long as the inflammatory process is confined to an appendix free in the peritoneal cavity, gradually changing to the right iliac fossa or to the location of the inflamed appendix. *Second*, nausea and vomiting, which come on

usually within two or three hours after the onset of pain. They are reflex, due usually to the over-distention of the appendix; rarely are there more than two or three efforts at emesis, usually only one, occasionally nausea only. *Third*, local sensitiveness to pressure. The inflamed and over-distended appendix is very sensitive to pressure and is guarded by involuntary muscular rigidity over the appendix, known as the *muscular defense*. *Fourth*, elevation of temperature, which, in acute appendicitis, is the manifestation of the absorption of the products of infection. It comes early, usually in from three to eleven hours after the onset of pain, as the quantity of infective material is early subjected to pressure, because of the small capacity of the appendix. It varies from 99.5° to 105.5°, depending upon the relative virulence and pressure and the resistance on the part of the patient. It is never absent in the acute infective variety, in the early stage. *Fifth*, leukocytosis is almost uniformly present. The degree of leukocytosis depends not so much on the presence of infection or its degree of toxicity as upon the ability of the leukogenetic organs to react. We have never observed leukopenia in our cases. Many times when the temperature is low the leukocytosis is high, and vice versa, so that the leukocytosis and temperature should always *both* be taken and their average values, as manifestations of infection, will always be found high.

This order of symptoms is present in 98 per cent. of cases of acute infection of the appendix.

The **differential diagnosis** in acute attacks of appendicitis involves an exclusion of (*a*) cholelithiasis; (*b*) acute intestinal fermentation; (*c*) renal calculus and retention; (*d*) acute tubal infection; (*e*) rupture of intra-abdominal abscesses; (*f*) gastric and intestinal perforations; (*g*) intussusception; (*h*) tuberculosis of the intestine, particularly of the ileum; (*i*) twisted tumor-pedicle; (*j*) typhoid fever; (*k*) acute cystitis, etc.

In lesions of the right iliac fossa the following frequent conditions should be specifically mentioned with some of their more conspicuous symptoms.

Tuberculosis of the cecum may exist as an ulcer or a tumor mass. The onset is insidious, the pain is constant, diarrhea alternates with constipation, the patient has afternoon rise of temperature and often shows evidence of tuberculosis elsewhere, there is ophthalmic or hypodermic tuberculin reaction, bacilli may be found in the feces, many times blood is detected. Preceding a hemorrhage there is elevation of temperature and colic.

Malignant Diseases of the Cecum.—The onset is exceedingly slow. Later the patient complains of pains, colicky in character, due to obstruction in carcinoma and to mural infiltration in sarcoma; constipation at first, soon followed by or alternating with diarrhea. Mucus and blood are often discharged, the patient becomes weak and deficient in hemoglobin, and there is evidence of secondary anemia. There is no elevation of temperature. Finally the acute intestinal obstruction from the neoplasm gives a picture resembling acute appendicitis.

Stone in the Ureter or Simple Ureteritis.—Ureteral colic is very sudden and severe. The pain is excruciating and radiates to the inguinal region, penis, and scrotum, or the vulva in the female. The patient has a constant desire to urinate, but is unable to pass more than a few drops at a time. Blood may be visible in the urine or detected microscopically. The temperature is subnormal and the patient shows other evidences of shock. The relief is sudden, due to the passage of calculus into the bladder, arrest in its progress, or its return into the renal pelvis. There is history of previous urinary disturbance. Palpation may reveal a calculus in the ureter. Pressure over the distended renal pelvis causes great pain. The *x*-ray often assists us. Ascending or descending infections of the ureter not infrequently give a very sensitive tubular mass in the iliac fossa which may be erroneously interpreted as the appendix.

Psoas Abscess.—There is frequently a history of injury to the back. Examination reveals a deformity or diminished mobility at the lumbosacral region. The *x*-ray shows deformity. The psoas abscess can be palpated as a fusiform or elongated and deep-seated mass which extends downward along the psoas muscle causing great muscular rigidity. Movements of the lower extremity involving tension on the psoas muscle give pain. The patient may have evening rise of temperature, thirst, and night-sweats, and will give a reaction to tuberculin. Leukopenia is manifest unless mixed infection is present.

Rheumatoid arthritis of the spine very frequently causes abdominal pain, is periodic in its character, and may closely resemble recurrent appendicitis. The pain, however, is not associated with temperature; there is hypersensitiveness and muscular rigidity, but the hand continuously compressed over the abdomen induces muscular relaxation and no mass can be felt in the iliac fossa. The fixation of the spine readily indicates the location of the true lesion. However, *rheumatoid arthritis is the cause of more errors in the diagnosis of abdominal lesions than any extra-abdominal condition with which we are acquainted.* This is due to the fact that the back is rarely examined, since the patient refers almost uniformly to the pain as abdominal.

Tabes Dorsalis.—The gastric and intestinal crises of tabes dorsalis are very frequently erroneously diagnosed as appendicitis. The mistake will not be made if attention is given to the essential symptoms of these two diseases. In tabes there is no elevation of temperature associated with the pain and vomiting; there is no zone of hypersensitiveness; no pronounced leukocytosis; there are present, usually, positive symptoms of tabes: the Romberg sign, the Argyll-Robertson pupil, the absence of tendon reflexes, perverted sensation in the extremities, and a history of specific infection with frequent repetitions of these acute attacks. Where the two diseases are associated as we have observed them, the presence of temperature, the hypersensitiveness, muscular rigidity, and mass in the right iliac fossa, with leukocytosis, indicate the coincident appendical infection.

Herpes zoster of the eleventh and twelfth intercostal and the first and second lumbar nerves may very closely resemble appendicitis.

The pain is continuous, intense and boring in character, and never colicky or intermittent. There is a superficial hypersensitiveness, distinctly confined to the area of nerve distribution, and absent on continued deep abdominal pressure, under which circumstance the muscular rigidity ceases. This must not be confounded with Dieulafoy's observation in children. The herpetic vesicles appear on the third or fourth day and must not be mistaken for cataplasm vesicles.

Typhoid Appendicitis.—It manifests itself usually on the third to the fifth day of the typhoid, by pain, colicky in character, associated with nausea and vomiting, muscular rigidity in the right iliac fossa, and leukocytosis. *The pain never precedes the temperature, as it always does in appendicitis.* The attack is too early in the typhoid for a perforation or thrombophlebitis. It rarely perforates the appendix in the early stage, as a pus infection does, but there are a number of recorded cases of late perforations of the appendix from typhoid ulcers, occurring in the second and third week of the disease, or at about the same stage as perforations in other portions of the intestinal tract. The typhoid ulcer of the appendix, therefore, does not demand an operation, as this would complicate the course of the typhoid. When perforation occurs in the later stage of the typhoid, it demands the same surgical treatment as perforations of other portions of the tract, from which it is impossible to differentiate it until the abdomen is opened.

Inflammations of Meckel's diverticulum may present the clinical picture of appendicitis, and even recurrences are possible. The cases are not numerous; ten or twelve only have been recorded.

Appendicular Colic.—This results from the effort made by the appendix to expel its contents, fluid or concretional. It is often recurrent, but is not associated with fever; it is always of short duration; abdominal tenderness and muscular defense are absent.

Thrombosis of mesenteric vessels comes on very suddenly, gives excruciating pains; there are no pathognomonic signs or symptoms. A diagnosis intra vitam is seldom if ever made. It, however, is secondary to other foci of infection or ulceration, as dysentery, hemorrhoidal, appendical, gall-bladder, or gastric infections. It may be metastatic from distant foci of infection.

Intestinal Lithiasis.—It bears no direct relationship to appendicitis. It may produce a similar clinical picture. The pain, however, is diffuse, and is felt along the colon. The feces contain mucus and "sandy" material, which are pathognomonic of the condition. With large enteroliths the symptoms are those of obturation ileus rather than those of infection in the abdominal cavity.

Right Upper Quadrant of Abdomen.—The lesions of the right upper quadrant which may simulate appendicitis are acute gastric, or acute exacerbation of an ancient ulcer, cholelithiasis, pancreatic calculi and acute pancreatitis. Pyloric and duodenal ulceration or perforation may closely resemble appendicitis. The pain, muscular defense, sensitiveness to palpation and percussion, however, are primarily most marked in the right *upper* quadrant. Infections and obstructions of the biliary

tract and pancreas not infrequently cause symptoms similar to those of appendicitis. The exquisite sensitiveness to perpendicular percussion (Murphy) is the most important differential sign in the acute stage, and the inability of the patient to take deep inhalation with the fingers hooked under the right costal arch indicates acute retentions or infections in the gall-bladder. The gall-stone colic is fairly characteristic and can be confounded only with the non-inflammatory appendicular colic. In cholecystitis there is frequently a history of previous portal-zone infection, typhoid particularly. The pain in gall-bladder diseases radiates toward the shoulder. Icterus may be present in severe infections of the appendix, and, on the other hand, may be absent in gall-bladder diseases.

Cases of obstruction of the common duct give a clean-cut history and a differential diagnosis is easily made.

Movable Kidney with or Without Dietl's Crisis.—Edebohls thinks that there is a close cause-and-effect relationship between a right movable kidney and appendicitis. An ectopic kidney may compress the superior mesenteric vein against the spinal column, thus producing a venous stasis in the appendix, which favors inflammation.

A painful movable kidney may occasionally simulate chronic appendicitis; with careful physical examination, however, the discrimination can be made.

Dietl's crisis is always associated with a right *movable* kidney. It is characterized by a sudden and marked pain in the abdomen, chills and fever, nausea and vomiting, which with the absence of physical signs and symptoms of infection in the region of the caput coli facilitate the diagnosis.

Cystic dilation of the renal pelvis with periodic retentions from ureteral flexion, valve formation, or muscular hypertrophies without infections give an obscure symptom-complex not dissimilar to recurrent appendicitis. Physical examination and ureteral catheterization, showing a large quantity of urine retained in the pelvis, establish the diagnosis.

Renal Calculus; Stone in Pelvis of Kidney.—Calculi give rise to sudden severe pain referred to the corresponding inguinal region and to the testicle. It may be associated with visible, but is always accompanied by microscopic hematuria. Pus cells are also present. There is a history of periodicity with rapid subsidence. The *x*-ray is of great value in many cases.

Pyelitis.—A history of infectious disease or long-standing secondary cystitis is almost always present. Repeated chills followed by a temperature of a septic character, subject to remissions, pus in the urine, constitutional symptoms, chronicity, and cystoscopic and ureteral examinations will confirm the diagnosis.

Perinephritic Abscess.—There is frequently a history of trauma, of sepsis in the pelvis of the kidney, or of a previous infectious disease. It may be cryptogenetic in its onset. Palpation may reveal a sensitive, possibly fluctuating mass situated high in the right hypochondrium or loin, usually immovable. Heavy fist percussion (Murphy) of the loin

with the patient's body bent acutely forward elicits extreme tenderness. The lumbar tissues may be infiltrated or edematous. The pain radiates toward the testicle. The urine may contain pus, but as this is occasional in appendicitis it loses its value.

Pyloric ulcer gives a history of late post-alimentary pain, two or three hours after meals. The gastric analysis shows hyperacidity in most cases. The stomach contents may contain blood, or if stasis be present sarcinæ; the feces often contain blood; there is loss of weight and diminished hemoglobin. Local sensitiveness is usual in the right hypochondrium; it, however, varies with gastroptosis. There are in many of these cases very pronounced and intensely acute attacks which last eight, ten, or twelve days and then completely subside, leaving not a single symptom of gastric or digestive disturbance until the next attack. In one of our cases of this class the ulcer on the stomach side of the pylorus was as large as a dollar and that on the duodenal side as large as a quarter.

The lesions in the right lower quadrant to be considered are: *In the male*, volvulus; intussusception; cryptorchidism with epididymitis or orchitis; intestinal incarceration or strangulation in subperitoneal pockets; incarceration in the cecal peritoneal pouches; incomplete hernia; infection of the iliac glands from disease of the external genitalia or lower extremity; peri-ureteral abscesses; infections of the vas deferens; cecal or sigmoidal diverticulitis (Mayo); omental torsion; appendicitis in hernial sacs; incarcerated or strangulated omental or intestinal hernia.

The diagnosis of a strangulation or obstruction of the bowel is not readily made. The pain comes on suddenly, frequently following a physical effort; it is located in one of the inguinal regions and is referred to the umbilicus. The patient shows evidence of shock; the temperature is normal or subnormal, *and is never elevated;* the pulse is weak. Vomiting is always present and persistent and consists at first of gastric contents, then of bile, finally of intestinal contents, and rarely of fecal material. The vomiting in appendicitis is never persistent and rarely exceeds three or four efforts. The abdomen becomes tympanitic and the pain generalized; it may suddenly subside and evidences of gangrene ensue—as: subnormal temperature, weak pulse, facies Hippocratica, and hiccup. Borborygmus is always a very pronounced symptom in mechanic ileus from any cause; it is always absent over inflamed zones or in the neighborhood of foci of acute infection. It precedes the pain and is commonly associated with colicky, wave-like exacerbations. Many times the peristaltic wave can be recognized through the abdominal wall, which is never the case in intra-abdominal infections except when associated with mechanic obstruction. Physical examination reveals an irreducible tumor in external hernial obstructions.

In the female a differential diagnosis between appendicitis and affections of the genitalia on the right side requires even more careful analysis. In diseases of the adnexa there is a history of chronic suffering, except in the acute cases of post-abortive or post-partum sepsis. A history

of intrauterine instrumentation, curetment, or acute gonococcal vaginal infection is very common in acute infections of the pelvic organs.

The attacks in appendicitis are sudden and the pains colicky in character, while in affections of the adnexa colicky pains are an exception. The sudden pains from infection of the adnexa are rarely ever referred to the epigastrium, the almost uniform point for appendical referred pains. Differentiation of the primary focus is practically impossible in cases where the appendix and tube are adherent and both infected.

Ectopic Gestation.—The pain is usually mildly colicky in character and is commonly present for a week or two preceding the explosion. The deferred menstruation, the diminished quantity of the previous flow, the atypical present flow, the constitutional evidences of hemorrhage, explosive in character, the signs of peritoneal fluid, the fixation of a mass in the right or left fornix, the absence of temperature elevation, and the finding of decidual cells in the vaginal discharge, all combine to favor the diagnosis of ectopic gestation or ruptured tubal pregnancy. The clinical picture of rupture is so sudden and so alarming that one can hardly mistake it for appendicitis.

Rupture of a tubal or tubo-ovarian abscess or twisting of an ovarian pedicle must also be excluded in the differential diagnosis of appendicitis, as they are among the most common of errors.

Among the abdominal conditions which may simulate appendicitis, irrespective of their location, are:

Acute Enteritis.—The pain is diffuse and colicky in character. Diarrhea is constant. The abdomen may be distended; vomiting is not constant; stormy peristalsis is always present. The temperature is slightly elevated, not exceeding 100.5°. The tongue is coated and thirst marked.

Acute pancreatitis, in one of its three forms: hemorrhagic, suppurative, or gangrenous. While the three forms differ somewhat one from another, a common clinical picture of the more acute manifestations may be given as follows: Sudden onset of intense pain, occupying the upper half and situated deeply in the abdomen. The patient usually sits down and refuses to move or be moved. The temperature is subnormal in the hemorrhagic form, soon followed by a chill and slight elevation of temperature; in the suppurative form the temperature may be elevated from the beginning. There is ordinarily a circumscribed mass, sometimes only a relative muscular defense between the ends of the ninth costal cartilages. Perpendicular percussion in the epigastrium causes great pain. The general condition is very alarming, the patient being dyspneic, cyanotic, and collapsed, often suffering severe hiccup. The feces contain fat; the urine albumin.

In **right pneumonia** with diaphragmatic pleurisy the pain is frequently referred to the appendical zone; there is also rigidity of the wall and suppression of peristalsis, and many times great tympany. Physical examination of the chest should never be neglected, especially in young subjects.

Chronic Appendicitis.—Some clinicians make a distinction between chronic and recurrent appendicitis, others use the expressions synonymously. The term "recurrent appendicitis" should be reserved for the cases which have recurrent, acute, inflammatory attacks, with all the essential symptoms of a primary seizure; the term "chronic" should never be applied to this class. All of these terms express distinct lesions of the appendix, and combined they do not cover all the pathologic changes found in this organ. There may be added adhesions, displacements, flexions, rotations on its axis, chronic retentions, foreign bodies, etc. The term "chronic appendicitis" should include all of the chronic symptom-producing conditions of the appendix other than those embraced in the preceding special headings. These appendical lesions produce grave disturbances of the digestive equilibrium, even where the anatomic changes in the appendix are comparatively small.

The *clinical picture* is not by any means definite or clear. Some complain of gastric disorders; others of intestinal symptoms; still others of a combination of the two. Some have anorexia and a symptom-complex suggestive of gastric ulcer, for which Longuet introduced a very appropriate term, "appendicular dyspepsia." Many suffer from constipation, others from a mild colitis. Micturition is more frequent. Some patients complain of a continual heaviness in the abdomen and of distress in the right side of the abdomen when lifting or bending the body. Patients generally lose weight, become pale and anemic; most of them are neurotics.

Physical examination may reveal some tenderness in the region of the caput coli; many times, however, such an examination is negative. Very frequently, in chronic cases, a considerable distention of the caput coli may be found. Temperature is, as a rule, normal throughout. The leukocyte count is in the vicinity of 8000 to 9000 and fairly constant.

The diagnosis of chronic appendicitis, appendical adhesions, torsion, irritation, colic, etc., should never be acted upon in an operative way until all the conditions mentioned under differential diagnosis have been excluded by a careful analysis of the history and symptoms and a systematic examination made for each of the diseases. If this plan is followed, an unnecessary operation will rarely, if ever, be performed.

Time for Operative Intervention.—The time for operative intervention may best be considered in four periods: First, early, within the first forty-eight hours; second, in the actively increasing inflammatory processes, from the second to the fifth day; third, in the subsiding inflammatory processes from the fifth day on; and fourth, in the intermediate stage—between attacks. From the previous statements concerning the clinical course and pathologic changes, it can be seen that the most favorable time for operation is within the first thirty-two hours of the attack; or, from a pathologic basis, before perforation of the appendix or infection or the peri-appendical tissues has taken place. The diagnosis can and should be made with accuracy in the great majority of cases before the end of the first twenty-four hours. From the symp-

toms and clinical course of the disease in the first forty-eight hours it is impossible to predict, with any degree of certainty, what the subsequent course of the case will be—that is, whether the tendency will be to subsidence and cure by the natural processes or to a virulent course, if not fatal termination.

The danger of operative intervention in the early stage is scarcely more than that of an exploratory laparotomy. The time required for the convalescence is not more than two and a half to three weeks. Drainage is, as a rule, not indicated and hernia improbable. Unnecessary early operations from errors in diagnosis should be very rare, as diagnosis in the first twenty-four hours is more easily and accurately made than at any other time, and is the time *par excellence* for operation. The patient would be relieved of his appendicitis without hazard, without prolonged illness, without the danger of unpleasant sequelæ, and without the possibility of recurrence, by the timely operation. To me there appears to be no excuse, no explanation, no logical process for, no justifying hope in, delay in this disease. Procrastination, under these circumstances, we do not regard as a manifestation of knowledge, experience, judgment, or *true* conservatism.

Should we operate in the second stage, during the increasing or spreading inflammatory process, which may mean anywhere from the second to the fifth day? In this stage we may have the circumscribed abscess around the appendix, an active inflammatory process of the neighboring tissues or organs, or the early pathologic changes of a circumscribed or general peritonitis. We often find the temperature and pulse high, meteorismus, intestinal paralysis, and acutely infected tissues, with manifestations of severe intoxication at this stage. These patients will not stand extensive manipulations. They are already fully burdened with the toxins, and this intoxication must not be increased or the patient will be sacrificed. Shall we operate? Yes; but the operation must be a limited one; that is, simple opening of abscess and relief of pus tension in the infected area with the removal of the appendix, if it be accessible and easily amputated. *There should be the least possible separation of agglutinations or other trauma to the infected tissues*, as agglutinations and adhesions are life-saving, both in circumscribing the process and in rendering the local tissues incapable of absorption. Many of the fatalities in operations for appendicitis have been due to the failure of recognition of these facts. Where the patient is apparently overwhelmed with the intoxication from a circumscribed or diffuse peritonitis or inflammatory process, we content ourselves with making a simple incision in the abdomen and relieving the pus tension by the insertion of a large drainage-tube *without irrigation, without sponging*, and *without manipulation* of the tissues. On the other hand, in the ascending stage of the disease, where the depression is not noticeable, when the intoxication is not severe, even when the quantity of pus is large, circumscribed or not circumscribed, the appendix is removed. The extent of the operation is governed rather by the constitutional symptoms of the sepsis than by the extent or character of the pathologic changes. One fact must never be lost

sight of in operating on this class of cases, and that is, that the pus is usually virulent, and when organized adhesions are present they must not be separated, as they expose the surface to acute absorption. Organic adhesions are rarely formed before the fifth day. Exudates must not be rubbed nor torn off, as they carry with them the endothelium and leave an abraded absorbing surface. The peritoneum should be considered similar to the skin; in the latter, while the epithelium is intact, there is practically no absorption; the cells are the shingles of protection; with the peritoneum, while the endothelial cells are intact, there is likewise practically no absorption, as there are no peritoneal stomata. The rule, therefore, which we follow is not to treat any of the active inflammatory conditions on the expectant plan, but to relieve the suppurating infected centers by opening and inserting an efficient drain; in the cases where the constitutional intoxication is mild the appendix is removed when accessible. In our work the appendix has been removed in nine cases out of ten operated in the second stage, while if attempted in the other 10 per cent. of cases, with severe symptoms of constitutional sepsis, we feel the majority of them would have been fatal. In the last five years' work in general septic peritonitis we have had forty-seven cases of perforative diffuse general peritonitis operated in the active stage with but two deaths, and neither of these from the peritonitis. The treatment after the operation in these cases consisted in placing and retaining the patients in a semi-sitting (Fowler) position (35 to 45 degrees) for three or four days, administering large quantities of saline solution per rectum, from six to fifteen quarts in twenty-four hours; the saline must be allowed to seep in, the tube remaining constantly in position. No water should be given by mouth, as the stomach never absorbs it directly, and under *these* conditions it does not readily transmit it to the intestines for absorption. Mild catharsis should be induced with small doses of calomel, beginning eight hours after operation.

I feel convinced that the great mortality which has been reported in operations in the second stage and under the clinical conditions mentioned above have, in a measure, been due to excessive manipulation, sponging, flushing, adhesion separating, and *prolonged operation*. The deaths in these cases of acute infection are due to the depression resulting from a sudden absorption of an overwhelming dose of bacteria and their toxins; this absorption is favored by the manipulations mentioned.

The treatment of an acute infective focus in the peritoneum should be the same as the treatment of similar infections in other portions of the body, for example, acute osteomyelitic foci in the ends of long bones. In these we open or tap without irrigation, sponging, curetting, or manipulation, and simply insert a drain. If we will treat the peritoneum with the same consideration, we will have equally gratifying results.

The sitting posture after operation allows the pus to settle in the most dependent portions of the peritoneum; there it is pumped out through the tube by the alternating diaphragmatic pressure. During transportation of cases of general suppurative peritonitis to the hospital and during the operation the patients should be kept in a semi-sitting position.

I do not consider any of these steps in the sense of *life-savers*, but their *combination* and the results obtained have revolutionized our ideas and prognoses in general suppurative peritonitis, as well as in acute and viciously septic appendicitis.

Operations in the third stage, or the stage of subsidence of the inflammatory process or retardation of the process of absorption, are not at all urgent, as in the first and second stages. To begin with, the destructive process has been overpowered by the local resistance of the tissue (the local immunity of tissue infiltration), and an effectual encapsulation of the pus has taken place; or it has emptied through ulceration into a neighboring coil of intestine; or is slowly destroying its boundaries in the line of least resistance and little absorption is taking place.

This process may continue for a considerable period of time, unless some accident should rupture the wall, or the pus should come in contact with a vein and thrombophlebitis with embolism ensue. The retained products of infection under these circumstances are always an element of danger, and in the hands of judicious and careful operators in this stage they can be conducted to the surface without hazard to the patient. By carefully coffer-damming the operative field the appendix can very frequently be removed without extensive separation of adhesions or scattering the pus over non-infiltrated areas. If a mass is felt in the iliac fossa, pelvis, or loin, and is readily accessible in any of these positions, it should be opened directly over the most prominent point and drained; this, however, must always be the exceptional route. When a case has progressed to this stage, the patient is in a position to be placed in the best operative environment and to have the best skill. Personally we prefer to open through the anterior abdominal wall in practically all of these cases and coffer-dam the field before opening the pus cavity. We have had eight deaths in this class of cases, two in which the free peritoneal cavity was not opened, but where the bulging abscess was simply opened and drained. In both of these incision was made in the anterior abdominal wall without entering the free peritoneal cavity. Either from the preparatory manipulation or from pressure on the abscesses during operation they ruptured below into the free peritoneal cavity. Both were large abscesses, one in a fourteen-day and the other in an eleven-day case. The accident was not detected, as the pus flowed freely from the abscesses when they were incised. The patients died from acute septic absorption seventeen and twenty-six hours respectively after operation. These cases occurred years ago, and since that time we never open directly into an abscess through an anterior incision; we always keep to the median side of the abscess and open into the free peritoneum, placing the coffer-dams before liberating the pus. Three were operations in the third stage, with a secondary elevation of temperature and manifestations of absorption; two of these died from acute sapremia from excessive separation of organized adhesions in efforts to remove the appendix in the presence of virulent pus. The other died from advancing gangrene with aërogenous infection in which the intestines and local tissues sloughed. The other three died of pylephlebitis with

multiple hepatic abscesses. This I do not feel could be attributed to the operation, but to the fact that the operation was late and thrombi had formed in branches of the portal vein.

In the third stage the presence of pus is always an element of danger, and we should not feel content until it is drained.

In the fourth or intermediate stage the question arises, Should we operate on every patient who has been through an acute attack of appendicitis? If so, why? The reasons favoring the operation are these: first, after an attack of appendicitis the patient is predisposed to recurrence; second, upward of 60 per cent. of the cases operated by us in the intermediate stage had had more than one attack; third, in the large proportion of the cases in which there was incision and drainage only of the abscess (which was a procedure frequently recorded by us in our first three hundred cases) the attacks recurred; in one patient we drained a periappendical abscess on three different occasions, always in the presence of severe sepsis, before we succeeded in inducing the patient to come in between attacks to have the appendix removed; fourth, the pathologic changes, such as adhesions, flexions, stenoses, etc., following a primary attack very much favor a recurrence; fifth, even if there were no danger of recurrence of the acute inflammatory conditions, the adhesions, fixations, stenoses, flexions, and retentions in the appendix produce sufficient disturbance of the digestive tract to demand an operation for their prevention or relief; sixth, recurrent infections are scarcely less dangerous than primary attacks (we recall one patient who died in the seventh attack); seventh, the appendix can be removed in the intermediate stage without danger. About two-thirds (upward of 2000) of our entire number of operations were in the so-called intermediate stage. In all of these we had one fatality, and that was from an acute, infective peritonitis, traceable to an assisting interne who had, without our knowledge, made an autopsy on a post-abortive peritonitis the night before the operation; two other patients operated on the same day were similarly infected. We had one case of severe but not fatal hemorrhage in the person of a physician, due to penetration of the deep epigastric artery by the closing figure-of-8 suture. In four of the intermediate cases all but a stump of the appendix was found to have been destroyed by the sloughing process. This is an extremely small number when one considers the severity of the inflammatory process and the number of cases in which the mucosa is gangrenous, as seen in the early operations. A partial or even complete obliteration of the lumen of the appendix is not rare.

Immediate Results.—The immediate results, if analyzed in successive hundreds, have varied materially. The greatest mortality was in our first one hundred cases, reaching, as it did, 11 per cent. We might add, however, that in that one hundred cases practically every one was an acute infection with pus perforation, more or less peritonitis, etc.; this embraces the period from March 2, 1889, to July 23, 1893. The number of deaths in each one hundred then gradually decreased until after the meeting of the American Medical Association at Atlanta in

May, 1896, when it will be recalled there was a great cry at that meeting against intraperitoneal operations, and particularly against the frequent operations for appendicitis. This was heralded through the journals, and the general practitioner who was in close contact with the public, believing it represented the consensus of opinion of the majority of surgeons, accepted it as a fact and hesitated before advising operations when unquestioned symptoms of appendicitis were present. This sentiment represented the ideas of men who conducted large clinics and were not in close contact with the public and the general practitioner. The penalty in lives was great. These clinicians saw mostly intermediate cases and did not realize the virulence, rapidity of destruction, and danger, nor the consequent vital importance of prompt and early action in the acute infective stage. In the year following this meeting our mortality reached seven in one hundred. Then there was another gradual decline, and the error of the physician was recognized, until the second epidemic of so-called conservatism ("expectant treatment") passed over the country and carried with it its quota of deaths, the mortality rising again to six in one hundred. Since that time there has been a steady decline in the number, until in our last one hundred operations there was a mortality of 2 per cent. It seems to me that every death from appendicitis is chargeable directly to the people, for not calling in the physician sufficiently early after the onset of the symptoms, or to the physician and surgeon for not acting promptly when they are called. We are sorry to admit that the latter represents the greater percentage. We should have *no* deaths from appendicitis, but *we are having them.* We should accept the force of numbers and experience to guide us against the culpable, if not criminal error of delay in this class of cases. It is not necessary that every physician should lose a case to learn the lesson, any more than every doctor should lose a case under chloroform anesthesia before learning to abandon it.

R. C. Coffey collected 13,445 cases from various large hospitals in the United States with a mortality of 7.4 per cent. In his analysis Coffey arranged the cases in five groups, grading them according to the average number of patients per staff surgeon. In these respective groups this average was 13, 7, 6, $2\frac{3}{7}$, and $1\frac{1}{6}$ cases of appendicitis per surgeon, to which the corresponding mortality was 6.3, 6.7, 7.1, 10.5, and 13.7 per cent. respectively. These statistics show that the mortality, in all the hospitals, is much greater than it should or would be if the cases were treated in time. It shows further that in the hospitals in which little experience existed the mortality was appalling. The mortality of the five most active operators—Ochsner, Mayo Brothers, Deaver, and Murphy—is 2.52 per cent.* Lanz, of Amsterdam,[15] operated seven hundred and ten cases without a death. He considers operations during the first and second day of the attack as well as in the interval perfectly safe. In contrast with these statistics, M. H. Richardson, in an analysis of seven hundred and fifty cases collected by him, gives an operative mortality of 18 per cent. The mortality in one hundred and sixty-one cases of general suppurative peritonitis of appendical origin at the Massachusetts General Hospital[16] for a period of five years, was 66 per cent.; the number of recoveries increased from 28 per cent. in 1899 to 48 per cent. in 1900. In the light of present results these figures are shocking.

Final Results.—The final results in appendicitis, as a whole, are very gratifying. When a patient has had the appendix removed, the

* Practical Medicine, Series 1907, vol. ii, p. 420.

rule is that he recovers from the operation, has as good if not better health than he had before, and is free from pain and inconvenience in the right iliac region. Rarely if ever is there disturbance of his digestive tract as the result of the disease or the operation. It is surprising how completely extensive adhesions, the result of diffuse inflammatory processes, disappear soon after the focus of infection is removed and the source of irritation eradicated. Prolonged packing and drainage tend to the formation of more firm adhesions than usually result from simple inflammatory processes themselves. With the exceptions of the adhesions following tuberculosis of the peritoneum there is no other disease in which they disappear so rapidly and completely as those that exist around an inflamed appendix. If the appendix perforates into an adherent intestine, a firm and organic adhesion remains, uniting it to the small intestine, the caput coli, the colon, or the sigmoid, as the case may be. All but these rapidly disappear, so that in an abdomen where six weeks previously an operation had been performed for the drainage of a large appendical abscess with extensive suppuration and adhesions, almost every evidence of the disease, except a fluffy velvety condition of the peritoneum, has disappeared. This is an every-day observation. In the average case the regenerative power of the endothelium over the intestine is great. Occasionally we find a tendency to keloid formations in the peritoneum or to the formation of cord-like adhesions which develop into strong, firm bands of sufficient strength to support the weight of the patient. Fortunately these are rare. If the appendix remains and becomes the source of chronic irritation after an attack of appendicitis, the adhesions often continue and remain there as a protection against a subsequent attack, lessening the danger of perforative peritonitis.

Results of Operation in Tuberculosis of the Cecum and Appendix.—Campiche[18] collected a series of three hundred and seventy-nine operations with a mortality of 18.6 per cent. Over one-third of the patients remained in good health for months and even years afterward, and about the same number died sooner or later from the disease or its effects.

The best method of operation is appendical or appendicocecal resection with side-to-side anastomosis. Eighty-six per cent. by this procedure recovered. When an artificial anus was instituted in addition to the resection, over 80 per cent. of the patients died. Extensive resections were also very fatal. Exploratory laparotomy was followed by permanent cure in only 15.7 per cent.

There were 86.4 per cent. of immediate recoveries from appendectomy; the tuberculosis in the neighboring intestine still persisted, however, so in reality only 13.6 per cent. of the twenty-two cases in which this operation was performed can be looked upon as permanently cured. The well-defined pathologic basis for surgical procedures in tuberculosis of the intestine is applicable here as elsewhere. All of the infected mucosa should be removed, even if it requires the resection of many feet of the tract. The tuberculous peritoneum does not need to be

excised, as it is self-reparative. End-to-side or side-to-side union should be performed with at least three rows of sutures if the peritoneum at the point of approximation is involved; if not involved, the button or two rows of suture should be used. Exclusion or "*auschaltung*" should be practised where excision is impracticable on account of adhesions or extensive invasion of the mucosa. Artificial anus should never be resorted to. Tuberculosis of the mucosa of the intestine practically never completely heals of itself; therefore, for radical cure, excision is very desirable. A tuberculous zone, if excluded from the fecal current, may remain quiescent for a lifetime, giving the patient practically no symptoms or inconvenience. This clinical fact greatly favors exclusion as the operation of choice under these conditions, since it involves so little danger to the patient and produces so little depression. Intestinal union in the presence of tuberculosis is difficult to secure, therefore greater care must be exercised in the technic of the anastomosis to avoid the all-too-frequent fistulas. Mixed infection of the peritoneum from the intestine produces a very dangerous and frequently fatal complication. Large doses of tuberculin produced the first and only complete healing recorded of tuberculous ulcers in the presence of fatal pulmonary tuberculosis, in the Moabit Hospital in 1890 and 1891. There is, therefore, now a ray of hope for the healing of tuberculosis of the mucous membrane of the intestine through the mild or opsonic doses of tuberculin.

Post-operative Complications.—As regards the immediate post-operative complications, the most common occurrences are peritonitis, ileus, pylephlebitis and thrombophlebitis, hemorrhage, fistulas, and hepatic, subphrenic, and other circumscribed abscesses.

Ileus is not an uncommon complication, due to plications or folds of the intestine, adhesions, torsions, and circumscribed inflammatory fixations, greatly favored by peritoneal tampons and somewhat by drainage-tubes. It frequently leads to a fatal termination, as it is difficult to differentiate its symptoms from those of progressive post-operative inflammation and infection.

W. Howard collected 3774 appendectomies from London hospitals; he found post-operative thrombosis in thirty-four cases and pulmonary embolism in eight. It is not at all uncommon to have a thrombophlebitis of the right or left femoral vein after the operation. Many explanations have been given for this occurrence, but none that we consider satisfactory.

In twenty years we have not had a single case of intra-intestinal hemorrhage. William Hessert in an able article reports three cases of post-operative hemorrhage into the colon. Two of the cases were interval operations; in one the appendix was mildly inflamed. The hemorrhage was due to the inversion of the appendical stump without ligation.

In our first one hundred cases we had fifteen fecal fistulas. In our more recent experience we do not average one fecal fistula for each one hundred cases. The fistulas are the sequence of gangrene or necrosis of the intestine from long-retained pus; failure of union of the stump of the appendix due to the infection present; and lastly trauma to the wall lowering its resistance, or laceration of it, in separating adhesions. In very viru-

lent infections gangrene of an extensive area of the intestinal wall may precede or follow operation. Fistulas usually close without operative intervention within four or five weeks; if they discharge beyond that time, excision of the fistulous tract with suture of the wall should be practised.

Post-operative adhesions in appendical operations in the great majority of cases entirely disappear; occasionally, however, they fix the intestine permanently to the scar, and sometimes many loops to one central point. The intestine may be rolled on itself and in that way produce a partial ileus.

The other post-operative complications are, in their method of production, pathology, and symptomatology, identical with corresponding pre-operative processes, which have been previously described.

The avoidance of adhesions is the keynote to the ultimate restoration to health after all abdominal operations. This perfection is attained by avoiding lacerations, trauma, tampon, gauze drainage, and, wherever possible, tubal or glass drains.

L. Jones[17] traced patients operated during 1900, 1901, and 1902 at St. George Hospital; only fifty-four of the eighty-seven operated made a perfect recovery after the operation. In two cases in which the appendix was not removed and only the appendical abscess drained, patients were re-operated for acute attacks.

We have observed a small number of cases in which patients complained of diffuse abdominal pain after the operation. Palpation of the abdomen showed an unusual irritability of the peritoneum, the slightest touch giving a pronounced pain in every portion of the abdomen. These cases of hypersensitiveness of the peritoneum occur about once in every two hundred laparotomies. They are uniform and classic in their symptomatology, and are not necessarily post-operative sequelæ, as they are often seen where no operation has been performed and where no pathologic condition can be found in the peritoneum to account for this condition. It is one in which the surgeon should always refrain from operating, as with each operation the hypersensitiveness is increased.

Non-operative Treatment of Appendicitis.—There are rare occasions when patients with appendicitis cannot be operated. If such be the case, the non-operative treatment must be instituted not so much as a matter of choice but as a matter of necessity.

The most interesting and valuable non-operative treatment is that known as "Ochsner's treatment." A great deal of judgment must be used in its application. In the hands of an indiscriminating practitioner this treatment will prove disastrous; it is often misinterpreted and used as a mantle for incompetency and an excuse for delay. It is applicable in cases where the surroundings of the patient are such as to make an operation impossible at the time, in cases where the patient cannot withstand the shock of an operation, or finally where there is no competent operator available.

This treatment is advised by Ochsner when the timely and desirable operative procedure has not been instituted within the first forty-eight

hours, and consists, in brief, of the total abstinence from food, the individual's vitality being maintained by nutrient enemas. Ochsner prefers to give the pre-digested foods instead of the ordinary nutrient enema. If the patient is considerably nauseated, the pharynx is sprayed with a 2 per cent. solution of cocain and the stomach washed out. "It is surprising often to find a great quantity of decomposing material in a patient's stomach after he has vomited so much that it seems impossible to find any more" (Ochsner).

Technic.—History.—The history of the technic may be divided into three stages:

First: The period in which the operation was performed with phlegmon of the abdominal wall.

Second: The period in which the operation was performed with circumscribed indurations in the abdomen, but without phlegmon of the wall or adhesions of the abscess to the wall. This was initiated by Kraussold and Krafft in Germany in 1888, and Gaston, Murphy, and McBurney in America in 1889. The incision first used by these operators was that known in the text-books as "incision for ligation of the right common iliac artery." In July, 1890, Murphy changed his incision to one two inches to the median side of the anterior superior spinous process and parallel to the fibers of the external oblique muscle, splitting them and incising the underlying peritoneum, thus making a transperitoneal operation. The same was used for the drainage of abscesses and for the removal of the appendix. Sonnenburg (1891) suggested a two-sitting operation with the hope of walling off the free peritoneum before opening the abscess. In December, 1890, I changed to the trans-rectus incision, from which I have never varied in typical cases. The Sonnenburg (1890) incision changed much with the location of the abscess, but was always an oblique one. The next important change in the division of the wall was that instituted by McArthur and McBurney (1893), known as the "gridiron incision." Since 1893 numerous changes have been suggested for the division of the abdominal wall, but they are not improvements on the gridiron muscle-splitting or trans-rectus muscle-displacing incisions.

The size of the incision has varied from the large 6- or 7-inch to a 2- or 3-inch incision. The greatest influence in reducing the size of the incision was exerted by the article of Morris, "The Inch and a Half Incision." The average incision of today is a little longer than that suggested by Morris, and in the hands of the inexperienced is to their advantage. The median incision is rarely resorted to where the diagnosis is established before the operation.

Technic of Operation.—The technic of operation must be adapted to the varied pathologic conditions and can best be described under five headings:

1. The procedure within forty-eight hours of the onset of the attack, while the process is still confined within the appendix.

2. In the circumscribed abscess stage with the disease in the common position (at McBurney's point).

3. With the abscess in varied erratic positions.
4. With general peritonitis.
5. In the intermediate stage.

During the first forty-eight hours, and particularly in the first thirty, the disease is confined within the limits of the appendix. It may be agglutinated to various organs, but it is easily freed, unless fixed by previous adhesions. Its base at this stage is commonly just above the right iliac artery. The incision here should be trans-rectus, just to the median side of the semilunar line, and bisected by a line drawn from the anterior superior spinous process to the umbilicus; it should be two inches in length and can be elongated as needed without cutting muscle-fibers. The two layers of the aponeurosis of the rectus muscle should be divided and clasped together in a hemostat at each angle, that they may be readily recognized for suture during closure. The fibers are then split or all displaced inward with the handle of the scalpel, ever noting the proximity of the deep epigastric artery. The peritoneum should then be elevated with two tissue forceps, one in the hands of the assistant and the other in the operator's, dividing it with a scalpel on the incline one-half inch below the summit of the elevation. By this method the intestines or omentum will never be cut in opening the peritoneum, as the air rushes in and instantly permits them to recede. If the appendix or intestines be adherent to the parietal peritoneum, elevation as described above is impossible. To avoid losing it, grasp the edge of the divided peritoneum with hemostats. Locate the appendix by passing the finger of the right hand into the wound, the finger-tip hugging the outer anterior wall, passing downward across the floor of the fossa over the iliac vessels, then upward along them until the finger hooks up the meso-ileum. Draw the ileum into the wound; it can then be readily followed outward to the caput coli, wherever it may be, and the base of the appendix thus found. (The meso-ileum is the one fixed structure in the right iliac fossa; it never changes, regardless of the displacements of the caput coli, which are many and extreme.) In making this sweep of the finger, if one encounters the swollen and inflamed appendix it may be elevated and brought up and the meso-ileum disregarded. This, however, is never as satisfactory as locating the meso-ileum and the base of the appendix and following and freeing it to its tip. Much time is lost by operators and some hazard added to the procedure when effort is made to find and pick up the caput coli without the above systematic procedure. The appendix is then lifted into the wound, if possible, without rupturing it, its entire mesentery clamped $\frac{1}{2}$ to $\frac{3}{4}$ of an inch from its appendical margin by an 8-inch compression forceps (see Fig. 429); a catgut ligature is then passed through the mesentery close to the cecum with an aneurism needle or hemostat and tied into the groove made by the compression forceps. The ligature therefore has in it only the vessels and peritoneum, the fat having been forced out. A ligature rarely, if ever, cuts through the mesentery, and, if this procedure be followed, cannot slip off when the mesentery is freed from the appendix. Divide the mesentery close to the appendix and up to the caput coli with scissors. A puckering suture of Pagenstecher linen

is now inserted around the base of the appendix; an overstitch should be made with this at the mesenteric attachment, which has the double purpose of ligating the small mesenteric artery and approximating the two peritoneal layers of the mesentery, giving an uninterrupted peritoneal surface around the base of the appendix. The appendix is then clamped $\frac{1}{2}$ inch from the caput coli (see Fig. 429) and a catgut ligature is tied in the groove made by the clamp. The appendix is then amputated just $\frac{1}{8}$ inch distal to the ligature. The caput coli is held by two tissue forceps, one on the appendico-mesenteric side, the other opposite, the catgut ligature cut, and the stump inverted with a hemostat holding a needle the blunt end of which protrudes $\frac{1}{3}$ inch; the purse-string suture is then tied firmly around the needle, at the same time withdrawing it. A continu-

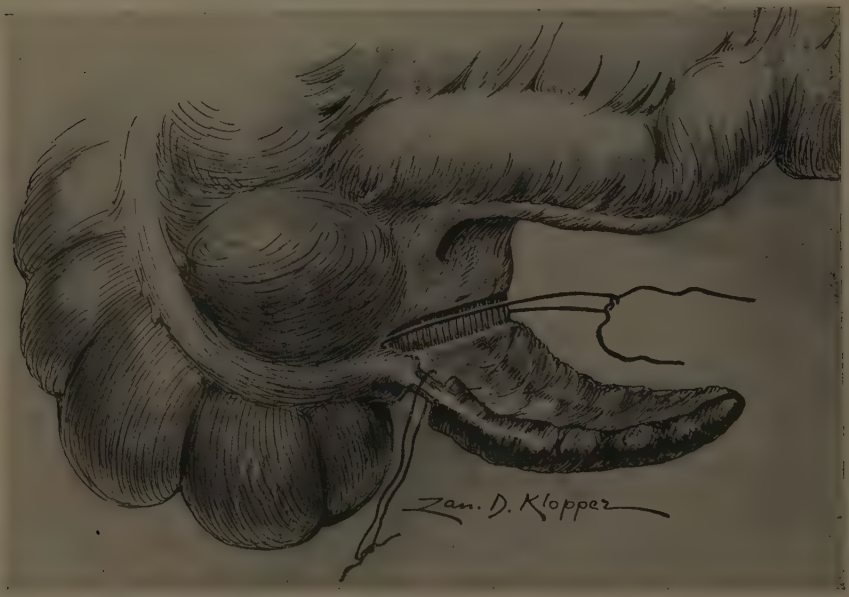


FIG. 429.—SHOWING THE GROOVES IN THE MESENTERY AND APPENDIX AS PRODUCED BY THE CLAMP AND HEMOSTAT, WITH LIGATURES INSERTED, PREPARATORY TO LIGATION.

ous Lembert suture of linen then approximates the peritoneum of the cecum over the stump and extends over the cut surface of the mesentery (see Fig. 430), making a third line of support against leakage. The appendix should always be ligated before embedding it, as fatal intracecal hemorrhage has occurred without this precaution (Hessert). Non-absorbable material should be used for the purse-string suture, because, if catgut were used and the needle penetrated the mucosa, it would at once be digested by the intestinal ferments and leakage occur. This has happened, and with one of the best of operators. The cecum is then returned into the abdomen. If the appendix has not ruptured and the mesentery is not infiltrated, drainage is unnecessary, regardless of the quantity of seropurulent (staphylococcus albus) fluid present. When the mesenteric

stump is infiltrated and the peritoneum blistered, a small tubular drain is always advisable.

The peritoneum is closed with catgut suture (No. 2) and the cut edge everted. In inserting the suture one should always bear in mind the proximity of the deep epigastric artery and vein. A suture passed through either of these might lead to serious and continuous hemorrhage, as occurred in one of our cases.

The aponeurosis is now united edge to edge with a No. 3 catgut brier stitch. An additional support may be given to this by figure-of-eight silkworm-gut stitches placed ¾ of an inch apart, the lower loop including the divided edge of the aponeurosis, and the upper all of the superstruc-

FIG. 430.—SHOWING THE FINAL LEMBERT SUTURE OF THE CECAL WALL AND APPENDICAL STUMP.

tures and skin. Before these stitches are tied the edges of the skin may be approximated either with a subdermal catgut or a horsehair or silk continuous suture. We prefer the horsehair.

A roll of gauze ¾ of an inch in diameter is now placed over the edge of the wound and the silkworm-gut tied taut over this. This makes a complete apposition of all of the cut surfaces with no *dead* spaces for wound secretion.

Six layers of gauze and one of absorbent cotton are placed over the wound, held in position by adhesive strips and a binder. The adhesive strips prevent displacement of the dressings beneath the binder. In cases not drained the dressing is not disturbed for ten days. The patients are permitted by some operators to get up on the third to the fifth day, but

we consider it questionable practice, preferring ten to twelve days in the recumbent or semi-recumbent position, as it requires a definite period of time for organic union of the divided aponeurosis, peritoneum, and skin to take place. The aponeurosis gives practically all of the abdominal support and *it* is the slowest to have definitive organic union. We consider the post-operative rest an important factor in hastening convalescence.

The aged, after the operation for appendicitis, as after all other operations, are transferred to the wheel-chair or placed in a semi-sitting posture and moved about at the earliest possible moment, as they suffer from hypostases which do not occur in youth or middle life.

With Abscess.—When abscess is present, the incision should be made on the median side of the highest point of the abscess, so as to open the *free* peritoneal and *not* the pus cavity. By this means one is able to outline the extent of the infection and the condition of the peritoneum beyond the line of suppuration, *e. g.*, if the abscess has ruptured into the free peritoneum during the preparation for the operation the accident will at once be recognized and the necessary drainage instituted; whereas if the incision had been into the abscess, the pus in the free peritoneum would not be recognized and might lead to a fatal termination, as was our experience before adopting this safeguard. When the peritoneum is opened and the abscess recognized, the intestines should all be walled off with gauze packing so as to entirely circumscribe the field. The agglutinations of the abscess wall should then be separated with the fingers, sufficient pus removed to permit inspection of the cavity, and if easily recognized, or if not more than four days have elapsed since the *onset* of the disease, the appendix should be searched for and removed. The anterior tenia coli, if followed, leads one to the base of the appendix. After five days the adhesions are vascular and organized and when separated leave absorbing surfaces, differing from the early condition of simple agglutination without vascularization, but with infiltration, "lymphatic coffer-damming," and local immunity, *where there is no absorption whatever.*

When the appendix is located it may be difficult to bring it into the field for ligation or suture. In these cases we ligate the mesentery and divide it down to the caput coli, clamp the stump of the appendix ⅓ inch from the cecum, ligate it *in the groove* produced by the clamp, and amputate it distal to the ligature, omitting the invagination.

In the presence of infiltration, Lembert sutures are impracticable, if not impossible, and are, indeed, unnecessary, as the simple ligature of catgut placed in this way suffices for the closure of the appendix. The inflammatory infiltration hastens the union and fecal fistula rarely results. A drainage-tube should now be inserted to the appendical stump and *stitched* to the lower angle of the wound.

When the appendix is deeply embedded, difficult to locate or remove, or where more than four days have elapsed, it should be permitted to remain, the abscess being simply drained. A great many lives are sacrificed by both experienced and inexperienced operators by making exces-

sively extensive operations, that they may feel that they have made a "*one-sitting complete operation.*" *This is often complimentary to their courage but derogatory to their judgment, and hazardous in the extreme to their patients.* It is impossible to enunciate definite rules applicable to all cases. This principle, however, should govern, as at all times; the patient should be conducted to a cure *with the least possible sum-total of hazard to his life*, regardless of the number of operations necessary, or his or the surgeon's personal convenience, likes or dislikes.

After the appendical drain has been fixed, if pus has escaped into the free cavity, an additional drain should be placed in the most dependent portion of the pelvis. The end should be guided by the fingers along the floor of the fossa over the iliac vessels into the pelvis, thus resting entirely behind the intestine; it should also be sutured to the lower angle of the wound. The tampons or packing should then be removed and the omentum or intestines permitted to rest closely around the drain. No packing or gauze should remain in the cavity after the operation is complete unless there be a gangrenous zone of intestine where perforation and leakage are expected. The peritoneum or abscess cavity should not be flushed, nor is the scrupulously complete removal of the pus essential. It *is* essential that the tubes prevent tension of the subsequent wound secretion or pus formation. Pus, except the specifically virulent varieties, which are very rare in the peritoneum, is not rapidly nor seriously absorbed, nor does it produce necrosis of tissue when free from tension. This applies to all positions of the body, and the peritoneum is no exception. The abdomen is closed as described above, a safety-pin is inserted in each tube, an additional precaution against its escape into or out of the peritoneal cavity. A large number of cases are reported where the tubes have slipped into the peritoneal cavity and then ulcerated into the intestine or bladder or remained indefinitely a source of irritation and danger to the patient. Some of these have made their appearance through ulcerations or secondary operations at inopportune occasions for the patient and under very embarrassing circumstances for the surgeon. A dressing is then applied, which should be changed as often as necessary for cleanliness. The cavity should never be irrigated or manipulated in any way. The tubes, however, should be rotated once every twenty-four hours. The Fowler position is adopted for forty-eight hours, and if the procedure was severe or prolonged or the sepsis great, proctoclysis should be practised.

The principles governing the technic of the operation of erratically placed appendical abscesses are practically the same as above, except when the abscess is deep in the pelvis in the female, when it may be drained through the posterior fornix, or when it is perinephritic on the right side it may be drained through the loin. When they are subphrenic they should be drained through the peritoneal cavity, beneath the costal arch, and never through the pleura, except where the pus is already in the free pleural cavity.

In general suppurative peritonitis due to a perforation of the appendix or to the rupture of a circumscribed appendical abscess into

the free peritoneal cavity—*i. e.*, a diffuse peritonitis the sequence of direct leakage from the intestinal tract through a hole in the appendix, or through a hole in the appendix and then through a circumscribed abscess which has ruptured into the peritoneum—I proceed as follows: Open the abdomen as in a case of primary appendicitis, locate and amputate the appendix to prevent further leakage. Insert a rubber drain to the stump of the appendix and another to the base of the vesico-rectal or Douglas pouch. *All manipulation of the intestine and sponging or flushing of the peritoneum for the removal of pus should be avoided.* The abdominal incision is closed, often with pints of pus remaining in the cavity. The operation should be the shortest possible and rarely needs to exceed ten minutes. The patient is then put in the extreme Fowler position and proctoclysis instituted. A pint and a half of normal salt, with a corresponding quantity (one dram to the pint) of calcium chlorid added, should be administered every two hours. Twenty c.c. of streptolytic serum we believe has advantages in the severely septic cases, and particularly in those with a low leukocytosis; it may be repeated twice each twenty-four hours until the symptoms subside. The opsonic index in colon bacillus infections can be elevated to five times the normal by the injections of colon bacillus vaccines after the plan of D. J. Davis, of Chicago.

The technic of the proctoclysis is simple, but unless given with appreciation of the principles involved the solution will be expelled by the patient. A fountain syringe or a can with a large rubber tube attached, terminating in a vaginal hard-rubber or glass tip flexed at an obtuse angle 2 inches from its tip, having numerous openings, is the entire apparatus. It should be inserted so that the angle fits closely to the sphincter and the tube then bound firmly to the thigh with adhesive strips, so that it may not be expelled. The can is suspended from the foot of the bed so that its base is six inches above the level of the patient's buttocks. Once the irrigating apparatus is thus placed, it need not be disturbed for several days, unless to increase or diminish the speed of influx. A pint and a half of solution is now placed in the can at a temperature of 100°, and should be kept at this temperature by applied heat (hot-water bags, thermolytes, or an incasing can of hot water). It should require not less than forty nor more than sixty minutes for the pint and a half of solution to percolate into the bowel, being uniformly absorbed in this period of time; but if administered more rapidly it will be expelled. *The control of the flow should never be governed by knots in the tube, forceps clamped thereon, or small openings in the tip.* The larger tube with many openings is used to provide for a sudden return of the flow into the can when the patient strains, wishes to expel the fluid or void gas. If, on the other hand, there be constrictions in the tube, the fluid cannot return into the can, but passes into the bed-linen. A larger quantity may be given in the severer cases. In a child of eleven we have administered thirty pints in twenty-four hours without escape of fluid.

Improvements (?) *on this simple technic have been disastrous in their results.* The proctoclysis is usually continued for three days, rarely as

long as five or six. Cardiac stimulants are rarely given. Strychnin, camphor, and caffein are, of these, the most valuable. We have treated on this plan forty-seven consecutive cases of peritonitis, of the direct perforative type, with two deaths, one, the sixteenth case, of a double pneumonia six days after operation, long after all of the peritoneal symptoms had subsided; the other, the forty-fifth case, died on the fourth day from an intestinal obstruction due to the twisting of the ileum around the omentum, which was adherent to an old hernial opening. He was operated for the obstruction the peritoneum was found normal, but he died six hours later from obstruction collapse. The results obtained by this treatment have so surprised me that I at first feared they were accidental. These cases are now uniform in result almost to a mathematic certainty when the details are carried out, which are based upon our knowledge of the physiologic and pathologic conditions of septic absorption, the local and constitutional immunity, and elimination of toxins. Ptomain or bacterial intoxication is similar to an alkaloidal poisoning; if the immediate and overwhelming effect can be overcome, inhibition of absorption and elimination will prevent a fatal result. The abdominal drains should be removed as soon as the pus ceases to discharge. We have reopened five cases for post-operative ileus and seven for secondary abscesses, in this series.

General Post-operative Treatment.—About 80 per cent. of the cases need very little, if any, special attention after the completion of the operation; the remaining 20 per cent. demand close watching, and half of these the exercise of the greatest skill to conduct them to a favorable end, and it is to this last 10 per cent. that we will turn our attention. These are already severely intoxicated, and have excessively septic processes, perhaps a local or general septic peritonitis. After the pus tension has been relieved by the opening and drainage and the source of the infection (the appendix) removed, the patient is placed in bed in the sitting (Fowler) position, with a back-rest. This favors the settling of the peritoneal exudates into the pelvis to the site of the drainage-tube; it is a physiologic fact that the pelvic peritoneum absorbs more slowly than the peritoneum above the umbilical level, and, furthermore, that encapsulation is favored by the anatomic structures in the pelvis and the activity of the omentum, sigmoid, and small intestines. Attention must now be turned to elimination of the products of infection. This is accomplished, first, by washing the blood by the administration of large quantities of fluids, rarely by the stomach or intravenously, occasionally subdermally, but most frequently per rectum. Since we have learned that the stomach does not absorb water, and that in peritoneal inflammations and sepsis it does not readily admit the water into the intestine for absorption, we have a good physiologic basis for ceasing to give water by the stomach and good explanation for the regurgitation of water administered in that way. We know from extensive clinical experience that very great quantities (two pints an hour) may be absorbed by the large intestine. Large quantities of water admitted into the circulation restore a fallen blood-pressure, favor osmosis and elimination, dilute the toxins,

quiet the thirst, lessen nausea, increase peristalsis and thus the expulsion of gases. There is some divergence of opinion through which of these channels we derive the greatest benefits. The stubborn fact remains, however, that the patient's comfort is greater, his condition improves, and he recovers. Strychnin may have some value as supplementing the proctoclysis. If alcoholics are given at all, they should be given by mouth, as they are rapidly absorbed by the stomach. Streptolytic serum is beneficial in those cases where local resistance seems to be meager and the leukocytic reaction feeble. It is decidedly indicated in the streptococcic types of infection with their exhilarative nerve phenomena. Calomel may be administered in small and repeated doses until effectual.

The Intermediate Operation.—The incision is the same as that for the early operation. The appendix is located by the meso-ileum or tenia coli route described under the same heading. When found it is often very difficult to free it from the intestinal wall, the iliac vessels, the parietal peritoneum, the gall-bladder or the subphrenic tissues. When the mesentery is short and the appendix embedded in any of these structures, the best plan is to divide the peritoneal and fibrous coats of the appendix, from base to tip, and shell out the mucosa. There is no hemorrhage and ligations are unnecessary.

The peritoneal and fibrous layers are closed with a whip-stitch of catgut, the appendix amputated, and the stump embedded as described under technic of early operation.

When the mesentery can be freed it is ligated, as described in the same technic.

Treatment of Adhesions.—Where extensive adhesions are present, they must be treated with great care, that no unnecessary abrasions be made. When abraded surfaces do exist, they should be covered by carefully applying to them the omentum, a neighboring intestinal coil, or by sliding adjacent peritoneum over it. The peritoneum abhors and will not tolerate abrasions; which should therefore always be covered by the surgeon and not be permitted to depend upon haphazard repair.

Post-operative Complications.—Ileus—intestinal obstruction following operation for appendicitis—may be classified as adynamic or paralytic ileus, so common after severe abdominal operation of every type, and mechanic ileus, a less frequent type, but one which leads to a fatal termination too often on account of the difficulty of making an exact diagnosis of its etiologic factors.

Etiology of the Adynamic Type.—(1) Muscular paralysis, from trauma and exposure; (2) local traumatic peritonitis; (3) local or general septic peritonitis; (4) embolism of the mesenteric vessels; (5) pylephlebitis; (6) strangulation of pedicles by ligatures (this was a most common cause of reflex paralytic ileus during the period of the mass ligature, which is now rarely applied without first producing a necrotizing compression before including it in the ligature).

The adynamic ileus, with its coprostasis, is rarely associated with nausea and vomiting. The tympany is considerable and the gas pains frequently recurring. There is marked borborygmus and often inability

to expel flatus or feces for days after operation. The symptoms become most urgent at the end of the second or beginning of the third day, and if they extend beyond that period they become alarming.

The treatment of this condition consists of repeated carminative enemas—preferably of alum water (½ ounce dried alum to the quart of water). This stimulates peristalsis and often gives prompt relief. If nausea or vomiting is present, repeated lavage must be practised, bearing in mind that repeated emesis of small quantities does not indicate an empty but an over-distended stomach, analogous to incontinence of over-distention in the urinary bladder.

Medicinally the best results in adynamic ileus are obtained by hypodermic injections of physostigmin (eserin) salicylate, repeated every two hours, in $\frac{1}{60}$-grain doses. Next in efficiency we consider the hypodermic injection of $\frac{1}{60}$ grain of atropin sulphate, repeated every three hours until constitutional effects are produced; this relieves the "gas pains." If these methods fail, there is great probability that the ileus is due to other than adynamic conditions, *i. e.*, that there is a mechanic obstruction.

Post-operative mechanic ileus may have many etiologic factors. It may be of the obturation or strangulation type. In the former we have a mechanic obstruction to the onward movement of the intestinal contents without material interference with the circulation in the intestinal wall. In the strangulation type there is not only a coprostasis but a venous and arterial stasis as well.

Etiology of Mechanic Ileus.—(1) Intestinal agglutination in transverse plications or angulations; (2) rotation or volvulus, the sequence of adhesion to inflammatory zones; (3) distortions and adhesions to hematomata; (4) compressions and angulations from tampons; (5) volvulus of intestine around old omental or intestinal adhesions; (6) incarcerations or strangulations in pockets (subperitoneal), beneath adhesive bands, in post-operative openings (mesentery, mesocolon, *e. g.*, after posterior gastro-enterostomy) in old hernial tracts; (7) intussusception.

The symptoms are essentially the same as those of mechanic intestinal obstruction under any other circumstances. It is in practice, however, difficult to say from the symptoms when a case ceases to be a post-operative adynamic ileus and becomes a mechanic condition. They consist of pain, wave-like and colicky in character, nausea and persistent vomiting, increasing directly with the time elapsed since operation, so that in the later stages there is a gulp every two or three minutes. The character of the vomitus is never fecal, but often of very offensive odor. The meteorismus increases with time; the degree of distention will depend somewhat upon the length of the intestine above the obstruction, as all of this becomes distended with both fluid and gas. In the early stages of the obstruction stormy peristalsis is manifest every few minutes, but this becomes less and less as the intestine becomes fatigued by the repeated efforts at propelling the intestinal contents. *Borborygmus is one of the most positive signs of a mechanic obstruction; it is never present in*

peritonitis or paralytic ileus. Coprostasis is persistent; at first there may be small quantities of feces passed after the enemas—material that was below the point of obstruction. This is likely to mislead; it should always be inspected by the surgeon, the nurse's estimate is not to be taken.

Gastric lavage often stops the vomiting and may give a fallacious sense of security unless this fact be carefully considered. If the treatment described above for adynamic ileus fails to produce results within a limited time, then it should be assumed that the obstruction is of mechanic origin, and the abdomen should be reopened and careful search made for the point of obstruction, meeting the indications on the basis of general principles. They should never be permitted to go to the stage of capillary cyanosis; if they are, they will probably terminate fatally promptly after operation. There is no more perplexing problem in all surgery than to decide when to reopen the abdomen with the symptoms of post-operative ileus. The more experience one has, the more fully one appreciates the inadequacy of the diagnostic guides.

Secondary adhesions following operations for appendicitis are usually very limited. They are increased, first, in cases operated late, both by the extent of the operation and the great degree of the pathologic changes; second, by drains and tampons; and, third, by prolonged suppuration after operation. One of the most striking features of abdominal surgery, as has been mentioned previously, is the degree to which adhesions and agglutinations around suppurating foci diminish or disappear, either with spontaneous drainage through the intestine or through an abdominal incision. Permanent fixations (post-operative) are the sequence of mal-management *from the secondary adhesion standpoint.* All manipulations, lacerations, severe handling, tamponing, and drainage other than tubular tend to the formation of adhesions, and must be avoided as completely as is consistent with the preservation of life. It seems to us that the permanent gauze drain or tampon should be omitted except where gangrenous perforation is expected. In operations on the subacute and intermediate cases all abraded and lacerated surfaces should be covered by peritoneum; the stumps of the appendix and mesentery should be carefully embedded beneath a fold of peritoneum. There is a tendency on the part of the peritoneum of some individuals to undergo fibrous changes, similar to the keloid formations of the skin. These cases should not be re-operated, as each additional intervention provides a new field for their development. The pain and discomfort from these adhesions are very annoying, and the patient can often locate them definitely; hence if operations are to be undertaken his word as to their location is to be given due consideration.

Phlebitis and Pylephlebitis.—The most common type of phlebitis is that of the left femoral vein, next to that the right femoral, occasionally in both simultaneously. These rarely suppurate and only very infrequently give rise to pulmonary or other infarcts. The treatment consists in rest, elevation of the affected limb, and external application of heat or cold (preferably the former) for the relief of the pain during

the first three or four days. Subsequently the limb should be wrapped in cotton and kept slightly elevated. The thrombosis rarely extends to the iliac vessels and it is only occasionally bilateral. It subsides rapidly and the subsequent edema and swelling of the leg disappear.

Pylephlebitis is much more common than is usually believed, and many of the cases classed as secondary peritoneal abscesses, typhoid appendicitis, etc., are really infections of the portal vein.

The veins of the caput coli and appendix are all tributaries of the portal system and, considering the frequency and degree of infection in this zone, the percentage of ascending venous infections is comparatively small. The infection is usually ushered in with chill and high temperature, some pain and distention of the abdomen, and occasionally nausea and vomiting. The temperature undergoes wide variations in the same day. The recurrence of the chills and fever is atypical, that is, *there may be two or three chills in one day, skipping the next two or three days, to become again manifest on the fourth or fifth*, and vary greatly in number and intensity. The temperature curve resembles the cholangitic angulation and contrasts greatly with the typhoid or ordinary septic curves. A striking feature is the absence of the coated tongue, the sordes, etc., that are so common with mucous-membrane infections in the portal zone, but this is true of venous infections in all parts of the body. Occasionally there is diarrhea; the liver and spleen become enlarged and sensitive, especially to fist percussion. Occasionally there are endocarditis and pulmonary infarcts; these, however, are late complications. The emaciation is rapid, septic icterus finally appears, and in from ten days to five weeks the patient succumbs. The post-mortem shows innumerable suppurating thrombi throughout the portal vein, multiple abscesses in the liver and spleen, occasionally fresh ulcers of the stomach, and, rarely, pulmonary and renal infarcts. These cases are many times operated for "secondary intraperitoneal abscesses," a procedure and humiliation that can be avoided if a careful analysis of the case be made.

The treatment is ineffectual and should be directed to the comfort and relief of the patient.

Hernia is not an infrequent sequel of the operation. It is a rare sequence of the intermediate operation and occurs with very little greater frequency after the early operation, as in both these an accurate apposition of the layers of the abdominal wall may be made and union is primary. It is common after operations in the abscess stage. A good estimate of its frequency may be drawn from Harrington's statistics. In two hundred and thirty-six cases eighty-five were completely closed at the time of the operation, and of these 3.5 per cent. showed subsequent hernia; eighty-eight were sutured down to the drainage-tube, or almost completely closed, the great majority with infection present. These showed hernia in 12.5 per cent. Sixty-three were treated by the "open method"; these showed 20 per cent. of hernias. The two striking features of these statistics are, first, that the primary complete closures should give as many as 3.5 per cent., and, second, that those treated as open wounds gave only 20 per cent. of hernias. An aseptic edge-to-edge

apposition of similar histologic layers of the abdomen with healing *per primam* should not give 3.5 per cent. hernias. If, however, fat and muscle are permitted to interpose between the edges of divided aponeurosis or transversely divided muscle-fibers, secondary hernia must be expected. If the rectus or transversalis muscle be divided at right angles to the long axis and sutured end to end, with primary union there is no danger of hernia. If, on the other hand, the sheath of the rectus be divided parallel to the long axis of its fibers and not accurately sutured, hernia will result. The smaller the opening for and the shorter the duration of drainage, the less the likelihood of hernia. It is somewhat surprising, and a matter not explained, why in such a large percentage of pus cases the layers of the abdominal wall unite primarily, regardless of the fact that they have been bathed in virulent pus during the operation. The clinical fact remains, however, that they do unite. We therefore should accurately approximate the layers down to the minimal openings for tubal drainage in all septic cases. Gauze strips, either incased in rubber or open, act as drains for a very short period of time only. Their capillarity is quickly

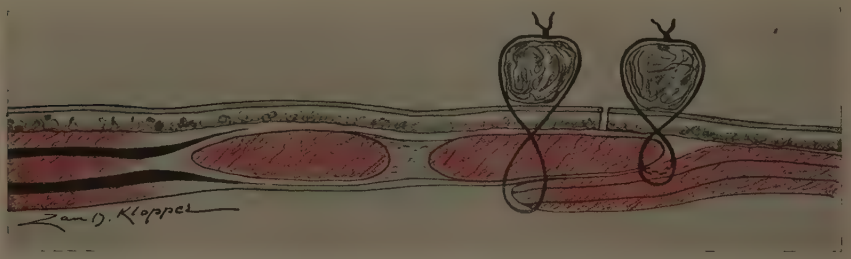


FIG. 431.—SHOWING THE METHOD OF IMBRICATION AND FIGURE-OF-8 SILKWORM-GUT SUTURE APPLIED (SEMI-DIAGRAMMATIC).

destroyed, they become plugs and cease to be drains. The cigarette and gauze drain is always inferior to the tubal drain. It is our belief that the "open treatment" can and should be abandoned, except in cases of threatened intestinal perforation by gangrene, or where the intestinal wall is injured during operation, and finally where the appendical opening is not accurately closed.

Methods of repair in post-operative cases may be divided into two classes: first, repair of the wall after complete healing; and, second, during wound healing. In the first instance we treat all by the imbrication or overlapping-flap method, as used by Andrews in inguinal and by Mayo in umbilical hernias, and never by edge-to-edge approximation of the fibrous ring. The imbrication may be transverse or longitudinal; we prefer the latter, and use the outer as the underlying flap. The closure may be made with chromicized catgut, kangaroo tendon, or insoluble material—silk, wire, linen, etc. We prefer the continuous kangaroo tendon, of the absorbable, and the figure-of-eight silkworm-gut through to the skin, of the non-absorbable, in that there is no permanently buried suture material in the latter. There are two rows of sutures, and me-

chanic support may be maintained for ten to fifteen days, until such time as pressure absorption of the tissues within the knot occurs. The silkworm-gut is supported on the skin by a small roll of gauze. (See Fig. 431.) The results of the imbrication method with an aseptic course are uniformly good and lasting.

The operation should be performed at the earliest opportunity after the hernia manifests itself, as hernias show a tendency to increase in size with time, and adhesions of the viscera to the sac become more and more frequent with repeated incarcerations.

Operations during wound healing (intermediate operations), in the presence of ichorous discharge and granulations, are classified as *suture* and *prosthetic* procedures. The suture may embrace edge-to-edge union of freshened granulation surfaces, the overlapping or imbrication fixation of the walls, or the tier (''*treppen-naht*'') edge-to-edge approximation of the layers. Any one of these plans gives a fair percentage of permanent cures, but enough of grievous disappointments to discourage the procedure. The prosthetic plans of repeated rows or scrolls of silver wire or filigree supports of Phelps and Bartlett, mattress sutures, plain or woven, of absorbable or non-absorbable material, give good results in selected cases. Silver wire or filigree is the best non-absorbable material, as it may become thoroughly incased in the tissue even in the presence of sepsis.

Post-operative Fistulas.—Where these persist beyond the usual time for repair of the wound, and where the quantity of discharge is great, as in cases of gangrene of the small intestine, early operation is demanded. At the end of six or eight weeks the inflammatory peritoneal adhesions will have disappeared except those produced by a deep destruction, which are destined to be permanent; the case is then in unfavorable condition for operation. The free peritoneum should be opened by an incision to the median side of the fistula. The adherent zone of the intestine is freed from the abdominal wall, except at the site of the fistula, so that the latter may be entirely encircled by the surgeon's fingers. The fistulous tract is then dissected free to and including the intestinal opening, lifted out of the abdomen, and the intestinal edges freshened and closed with a Czerny-Lembert Pagenstecher linen suture and dropped into the peritoneal cavity. If the intestinal edges are infiltrated, the line of union may be supported by a flap of omentum (Senn) or the proximal portion of the intestine turned U-shaped and sewed over the line of union by catgut suture (Murphy). This makes a very efficient splint and insures a rapid agglutination and speedy organic union. *Suture of intestinal fistulas should never be attempted without freeing the attachment to the abdominal wall.* The great majority of appendical fistulas close without surgical intervention in ten or twelve days. Sinuses are often slow in healing. The process can be hastened greatly by Bier cupping or *x*-ray treatment. The ordinary breast-pump, applied from one to two hours a day, is an excellent substitute for the Bier instrument.

In all slowly healing and indolent granulating cavities of the abdominal wall following operation the Bier treatment should be instituted. Its most striking effect, however, is obtained in tuberculous sinuses or fistulas.

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CHAPTER LXIV.

SURGERY OF THE EAR.

By Edward Bradford Dench, M.D.,
NEW YORK CITY.

Anatomy of the Ear.—From an anatomic point of view, the organ of hearing may be divided into two portions: a conducting mechanism, which includes the auricle, external auditory meatus, and middle ear, together with the mastoid cells and Eustachian tube; and a perceptive apparatus, which includes the bony and membranous labyrinth, the trunk of the auditory nerve and basal nuclei, the fibers joining these nuclei with each other, as well as the association fibers which join the various nuclei with the cortical perceptive areas.

It will be possible to consider but briefly the various anatomic points of interest. In the anatomy of the conducting mechanism we should remember that the external ear, or auricle, simply conserves the purpose of gathering sound waves and of reflecting them into the external auditory canal, whence they are conducted to the membrana tympani and the labyrinth through the ossicular chain, to the perceptive mechanism. In considering this conducting apparatus we should remember that the external auditory canal in the adult consists of two portions: a fibrocartilaginous portion, which measures an inch in length; and a bony portion, which measures half an inch in length. This is very well shown in Fig. 432. In addition, we should remember that the external auditory meatus is entirely fibrocartilaginous in structure in infancy. The bony meatus does not exist at birth, and is formed during development by the outward growth of the auditory process. The accompanying illustration of the temporal bone and membrana tympani of the newborn infant will perhaps give a clear idea of the condition present at birth. (See Fig. 433.) In early infancy the superior and inferior walls of the external auditory canal are in contact, and a view of the drum membrane can be obtained only by separating the walls. The superior wall of the canal, being firmly attached to the external surface of the

Fig. 432.—Sagittal Section through External Auditory Meatus, Membrana Tympani, and Middle Ear of an Adult (Dench).

temporal bone, is immovable, while the inferior wall is easily separated from the superior wall by traction upon the auricle, pulling the auricle downward, backward, and outward.

In examining the ear of a young child we should therefore remember that in order to obtain a view of the membrana tympani, which forms the fundus of the canal, the auricle must be pulled downward, backward, and outward. In the adult, as before stated, the inner half inch of the external auditory meatus is bony. In adult life the bony portion of the canal joins the outer cartilaginous portion at an obtuse angle, both from above downward and from behind forward. Consequently, in order to view the fundus of the canal in an adult, the axes of the bony and cartilaginous canals must be brought into the same straight line. As the outer portion of the canal alone is composed of soft tissues, this result can be obtained only by raising and at the same time pulling backward the outer portion of the canal. This is accomplished by outward, upward, and backward traction on the auricle. The lengths of the fibrous and bony canals, respectively, are of importance mainly in the extraction of foreign bodies through an incision. If an incision is made behind the auricle, by dissecting out the fibrous canal we are able to approach more nearly to a foreign body impacted in the fundus of the meatus.

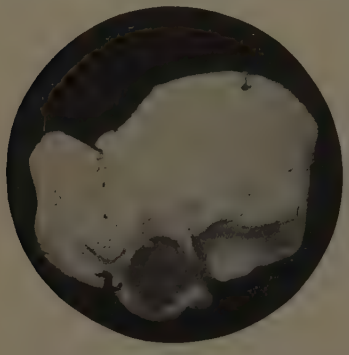

FIG. 433.—TEMPORAL BONE OF INFANT AT BIRTH.

In the anatomic consideration of the middle ear, we should remember that its outer wall is formed by the membrana tympani, this membrane also forming the fundus of the external auditory meatus. The membrana tympani is divided into two portions: a lower portion, or membrana tensa, representing that portion of the drum membrane attached to the groove in the auditory process. The upper portion of the drum membrane, or membrana flaccida or Shrapnell's membrane, fills in the space between the anterior and posterior spines of the auditory process or tympanic ring. Its upper attachment is really the squamous plate of the temporal bone, just behind the posterior root of the zygoma, and it is really a portion of the periosteum of this part of the temporal bone.

This division of the drum membrane into two portions, an upper portion or flaccid membrane, or membrana flaccida, and a lower portion or tense membrane, or membrana tensa, is of the utmost importance clinically.

Within the tympanic cavity is the ossicular chain, composed of the malleus, incus, and stapes. The malleus is attached by its manubrium to the drum membrane, and the manubrium mallei passes downward and backward through the membrane to a point just below the center of the membrana tensa. The upper extremity of the manubrium mallei is marked by a prominence, known as the *short process of the malleus,*

and a horizontal line drawn through this short process marks the separation between the membrana tensa below and the membrana flaccida above. The short process presents as a prominent bony point, pushing the drum membrane outward at a point about 1 or 2 mm. below the superior wall of the external auditory canal. As the ligaments which hold the malleus in position, and about which it rotates, all pass through the short process, the position of this process is fixed and immovable, no matter what changes may take place within the tympanic cavity. Its importance as a landmark, therefore, cannot be overestimated. The entire manubrium mallei thus lies below the short process. The neck of the malleus lies opposite the membrana flaccida, while the head of the malleus and the body of the incus are completely inclosed in a space above the superior canal wall, and are entirely surrounded by bony walls. This cavity is known as the *tympanic vault*, and is sometimes called the *tympanic attic*. From the bodies of the ossicula, supporting the ossicles, ligaments pass to the adjacent tympanic walls, and in addition to these ligaments there are also certain folds and reduplications of mucous membrane which pass from the bodies of the ossicula to the adjacent tympanic walls. These reduplications follow generally the course of the several ligamentous structures, although their position is extremely varied. From a clinical point of view, the importance of this arrangement lies in the fact that while the lower portion of the middle ear consists of a cavity with an inner, posterior, inferior, and anterior bony wall and an outer fibrous wall (the drum membrane), the upper portion of the tympanic cavity is bounded on every side by bone, except at its lower and external portion, which wall is formed by the membrana flaccida, or Shrapnell's membrane. The vault of the tympanum or the upper portion of the tympanic cavity is in relation above and in front with the middle cranial fossa; behind it is in relation with a series of pneumatic spaces, known as the "mastoid cells," with which it is intimately associated, and its connection with which should never be forgotten by the surgeon, because any inflammation, however slight, of this portion of the tympanic cavity probably involves, to a greater or less extent, the mastoid cells. The thickness of the superior wall of the tympanum varies greatly with the age of the patient, and in different subjects of the same age. In infancy this roof is invariably thin and almost parchment-like. In most adults it is thicker, but in some it may not attain a much greater thickness than is normal to infants. In certain subjects prolongations of the dura mater extend into the tympanic cavity.

As the upper part of the cavity is of more importance to the general surgeon than is the lower part, more space will be devoted to the anatomy of the upper portion than was used in describing the lower portion.

The mastoid cells consist of numerous pneumatic spaces which communicate directly with the tympanic vault. Only one of the pneumatic spaces is invariably present. This constant space is of considerable size and is known as the *mastoid antrum*. The mastoid antrum should really be considered a part of the middle ear, as it is, in fact, a prolongation backward and upward of the tympanic vault. The distribution

of the other pneumatic spaces in the mastoid may vary considerably, from those extreme cases of sclerosis where the only pneumatic space is the mastoid antrum, to cases in which the entire mastoid process is composed of pneumatic spaces, extending from the zygomatic arch in front to the mastoid tip below, and, posteriorly, beyond the mastoid into the occipital bone itself. Clinically, the pneumatic spaces which interest us most are: first, the antrum; second, the cells at the mastoid tip, which, in the average pneumatic mastoid are very well developed; and, third, those pneumatic spaces which develop in the root of the zygoma, and may extend a considerable distance into this structure, and also cells which may develop beneath the zygoma in the squamous portion of the temporal bone itself. (See Fig. 434.)

It can readily be seen, therefore, how any inflammation involving the middle ear, and particularly involving the tympanic vault, may extend rapidly to the pneumatic structures of the mastoid, giving rise to symptoms of an inflammatory nature, involving a greater or less anatomic area, depending entirely upon the extent to which the pneumatic spaces are developed in the individual case. Above, the pneumatic spaces of the mastoid are in relation with the middle cranial fossa, of which they form the floor. Posteriorly, these pneumatic spaces are in relation to the lateral sinus and the anterior surface of the cerebellum. Below, they are in relation to the digastric fossa, and, deeper, to the anterior surface of the cerebellum and supero-posterior portion of the jugular bulb.

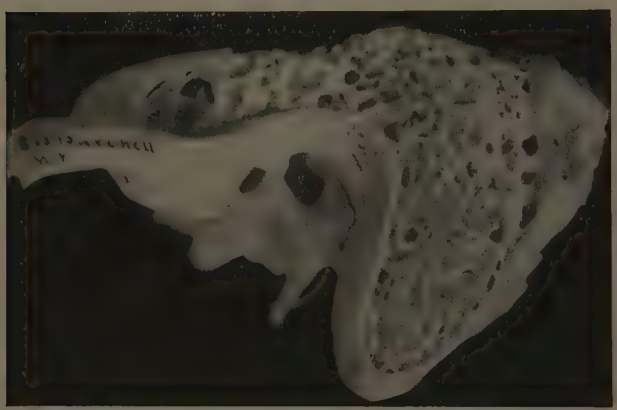

FIG. 434.—PNEUMATIC MASTOID. CELLS AT TIP, AT ROOT OF ZYGOMA, AND BENEATH ZYGOMA ARE SHOWN. (Author's specimen.)

A word should be said in regard to the narrow passage which joins the mastoid antrum to the tympanic vault. This is known as the *aditus ad antrum*, and varies considerably in size in different subjects. From a surgical point of view, it is important from the fact that its posterior boundary is the horizontal semicircular canal, and its postero-inferior boundary the aqueductus Fallopii, which lodges the facial nerve.

It can easily be seen from these anatomic relations how readily an inflammation involving the middle ear can spread either to the contents of the middle cranial fossa, on the one hand, or to the lateral sinus or the cerebellum, on the other.

In the lower portion of the tympanic cavity we have simply to note that in its upper posterior portion it lodges the long process of the incus, the incudo-stapedial joint, and the stapes, which is lodged in the oval window. Below this is the niche of the round window. Externally is the promontory which is formed by the first turn of the cochlea. Running horizontally across the cavity, above the stapes, is a prominence, the *aqueductus Fallopii*, which lodges the facial nerve. The position of this structure must always be remembered in major operations upon the tympanic cavity. Upon the anterior wall of the cavity are the openings of two tubes. The upper tube lodges the tensor tympani muscle. Immediately below this and separated from it by the processus cochleariformis is the Eustachian tube, which communicates directly with the vault of the pharynx. The inferior wall of the middle ear is bony, and forms the roof of the jugular bulb.

Means and Methods of Examination.—In order to thoroughly examine the ear, a good source of light is necessary. The light must be concentrated upon the parts, either by means of the concave reflecting mirror, worn upon the forehead, or by means of a focusing forehead lamp. (See Fig. 435.) If the reflecting mirror is used, the source of illumination may be either daylight or, preferably, some of the artificial sources of illumination. The light from the ordinary candle, if no other source of illumination can be found, is sufficient, although gas-light or electric light is much better.

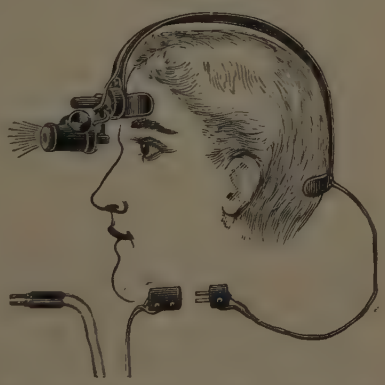

Fig. 435.—Electric Lamp Worn upon the Forehead.

In examining the ear it is wise to make a careful inspection of the auricle and of the meatus under full illumination, prior to the insertion of any instrument into the canal. In this way the surgeon will recognize pathologic conditions at the entrance of the meatus which might otherwise entirely escape observation. Palpation about the ear also affords much information. It should be remembered that in infants tenderness on pressure in front of the tragus is usually indicative of an inflammation of the middle ear, owing to the fact that the inferior wall of the external auditory canal in young infants lies in immediate contact with the drum membrane. In the adult the bony canal is present, and tenderness on pressure in front of the tragus is invariably indicative of an inflammatory condition of the external auditory canal rather than of the middle ear. The same may be said of pain on manipulating the auricle.

In order to thoroughly examine the external meatus, it is necessary to employ an aural speculum. (See Fig. 436.) It should be remembered that this instrument is not for the purpose of dilating the meatus; consequently it should not be crowded into the canal, but the size of the instru-

ment should be just sufficient to simply separate the meatal walls. In order to obtain a view of the fundus of the canal, that is, of the drum membrane, it will be necessary, in the case of an infant, to draw the auricle downward, backward, and outward, so as to separate the lower wall of the meatus from the upper wall. (See Fig. 437.) In the adult, owing to the fact that the inner portion of the external auditory canal is bony, and the outer portion fibrocartilaginous, and that these two tubes are joined to each other at an angle, it will be necessary, after introducing the speculum, to bring these two bony tubes into the same straight line, and this is done by drawing the auricle upward, backward, and outward. The examination is best conducted if the speculum is grasped between the thumb and index-finger of the left hand and inserted into the canal, while the second and third fingers grasp the auricle, exerting traction in the direction desired. Then, by tilting the speculum between the thumb and index-finger, the entire surface of the walls of the meatus may be examined and the drum membrane may be inspected.

FIG. 436.—GRUBER'S AURAL SPECULUM.

In inspecting the canal, its caliber and color should be noted. The caliber of the meatus varies considerably in conditions of health, but any unusual narrowing of the canal should be regarded as pathologic. If the narrowing is present close to the meatus, it is indicative of an inflammation of the canal, while if it occurs close to the drum membrane, it is always indicative of serious middle-ear inflammation, with beginning involvement of the mastoid cells. Under normal conditions, the color of the canal is the same as that of the auricle. Any injection, therefore, of the canal should be regarded as a sign of disease.

FIG. 437.—DRAWING FROM SPECIMEN AT BIRTH (Dench).

Traction must be made downward and backward to expose the membrana tympani.

After inspecting the meatus, in the manner described, the drum membrane should be next examined. The drum membrane is placed at an obtuse angle with the upper and posterior walls of the external auditory meatus, the membrane being inclined downward, forward, and inward. It is important to first locate the short process of the malleus, which appears as a bony prominence, pushing the drum membrane outward, as it were, into the canal, at a point about a millimeter from the superior wall of the external auditory

meatus. From the short process the long process of the malleus extends downward and backward as far as the center of the drum membrane. (See Fig. 438.) The point of termination of the long process is known as the *umbo*, and from this point there is a triangular light reflex, extending anteriorly and slightly downward. Under normal conditions the drum membrane is slightly retracted at its center, and it is this which gives rise to the light reflex.

Four characteristics of the drum membrane should be observed: First, its integrity; second, its position; third, its color; and fourth, its luster. By the integrity of the drum membrane I mean whether the membrane is intact or whether there is some solution of continuity: If the membrane is intact, the observer on examination will be able to follow the posterior wall of the canal across the fundus to the anterior wall without observing any break. He will also be able to follow the superior wall across the fundus to the inferior wall without observing any solution of continuity. If a perforation exists in the drum membrane, the observer will be able to recognize it by an increased depth of the fundus at this particular point. In position, the drum membrane may be either normal, retracted, or bulging. The retracted membrane does not interest the surgeon, and consequently will not be considered here. The bulging drum membrane is usually indicative of fluid in the tympanic cavity. The bulging or protrusion into the canal generally occurs in the posterior portion of the drum membrane. This bulging may be uniformly in the posterior portion or may simply involve the upper posterior portion. Where the bulging is uniform, it is indicative of inflammation in the lower part of the tympanic cavity, that is, in the atrium. Where this bulging is confined to the upper posterior portion of the membrane, it is indicative of an inflammation in the tympanic vault, and should always be regarded as a serious condition.

FIG. 438.—THE NORMAL MEMBRANA TYMPANI (SOMEWHAT DIAGRAMMATIC) (Dench).

The color of the drum membrane, under normal conditions, is pearly-white. A slight congestion of the drum membrane may take place as the result of manipulation of the auricle or of the insertion of instruments into the canal. It is characterized by redness along the periphery of the membrane and along the malleus handle, the remainder of the membrane retaining its normal color. If the membrane is uniformly reddened, this condition is pathologic, and is always indicative of an inflammation within the tympanic cavity. It is important to bear in mind that when the drum membrane is red, it may be red throughout its entire extent, which is indicative of an inflammation of the lower portion of the tympanic cavity, or this redness may be confined to the upper posterior portion of the membrane; that is, to that part of the membrane lying above the short process of the malleus and its immediate vicinity. This is an exceedingly important condition to recognize, as it is always indicative of an inflammation of the tympanic vault and is always accompanied by more or less involvement of the mastoid cells.

The luster of the membrane is always an important characteristic. Under normal conditions the membrane has a luster not unlike that of the pearl. Total absence of luster, that is, a dead-white membrane, especially in young children, is always indicative of an acute inflammation. Absolute loss of luster is due to necrosis of the superficial epithelial cells as the result of inflammatory process. Whenever the membrane has this dead white appearance, the surface should be mopped off with a cotton-tipped applicator, which will remove all these dead epithelial scales and will reveal the surface of the drum membrane bright red and inflamed beneath.

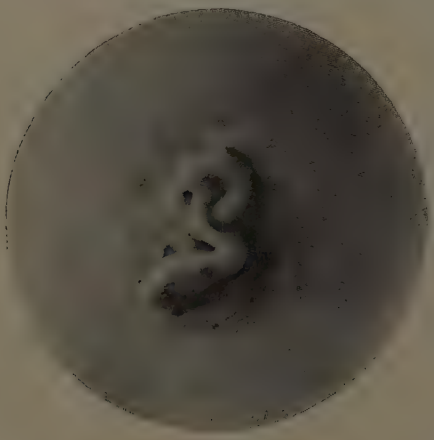

FIG. 439.—MICROTIA.

Compare this illustration with Fig. 440, which shows the local condition as corrected by operation.

Malformations.—Malformations of the auricle are rather uncommon. They may involve either the entire auricle or simply portions of the auricle. Extensive malformations are usually unilateral. The most common is the condition known as **microtia,** where the entire auricle is malformed. (See Fig. 439.)

In this variety of malformation we usually have the external ear presenting as an irregular, immovable mass of fibrocartilaginous tissue, attached in the situation of the auricle. There may be one or more auricular appendages. Usually there is one cartilaginous prominence in front of the malformed auricle, corresponding to the tragus. The external auditory canal is usually wanting in all of these subjects.

The *surgical treatment* can be considered under two heads: First, relief of the external deformity, and, second, measures for the restoration of the external auditory meatus. Plastic surgery can do much for the relief of the external deformity. The two figures appended show a case of this character, operated upon by the author, the photographs being taken, respectively, before and

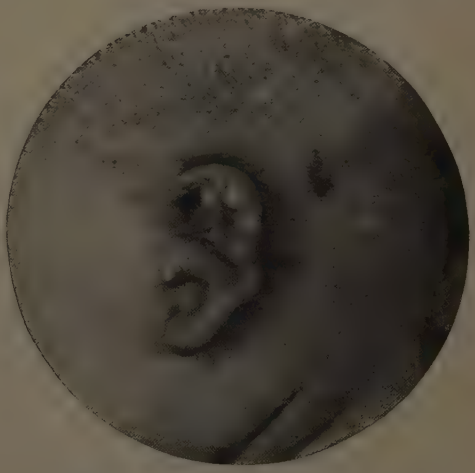

FIG. 440.—MICROTIA, AFTER OPERATION, SHOWING RESULT OBTAINED IN PATIENT SHOWN IN FIG. 439.

after operation. (See Figs. 439 and 440.) In this case the operative treatment consisted in first dissecting up the tegumentary covering from the anterior surface of the auricle and resecting a portion of the deformed cartilage. This allowed the auricle to be unfolded. An incision through the helix was also necessary in order to complete this unfolding. The integument dissected from the anterior surface of the auricle was stitched into position as well as possible, but a large raw surface still remained on the anterior surface of the auricle. This was covered with a Thiersch graft. An incision was then made about three-quarters of an inch behind the line of auricular attachment, and the skin was dissected up from the underlying tissue, this dissection being continued over the posterior surface of the auricle. In this way a large cutaneous flap was formed, which approximated in size the area of the posterior surface of the normal auricle. This flap was fastened, at the line of auricular attachment, with fine catgut sutures. In this way an auricle, somewhat unshapely, but more sightly than the previous deformity, was produced. An attempt was then made to slide the integument forward to the line of posterior auricular attachment by dissecting up the posterior flap from the surface of the skull. This effort was unsuccessful, however, as the stitches pulled out, leaving a denuded area behind the ear. This area was subsequently covered with a Thiersch graft, and the result is shown in the accompanying illustration (Fig. 440).

In each case the surgeon will be obliged to use his own ingenuity, the chief points being to first free the integument from the anterior surface of the auricle, and take out so much of the cartilaginous framework as is necessary to allow the auricle to be folded into a somewhat normal position. The anterior flaps are then stitched into the best possible position, and any denuded surface remaining is covered with a Thiersch graft. In order to increase the breadth of the posterior surface of the auricle, the plan spoken of in the case already related should be employed.

Regarding the advisability of attempting to establish an external auditory meatus in these cases, researches in this direction show that where the external ear is deformed and the meatus congenitally occluded, there is almost invariably some defect either in the conducting mechanism or in the perceptive apparatus, so that, even if the surgeon should be able to form an external auditory meatus, the hearing of the patient would not be improved. The efforts of the surgeon, therefore, in these cases of deformity, should be limited to attempts to relieve the external deformity, without efforts to form an auditory canal. In cases where a plastic operation cannot be performed, it is better to amputate the entire auricle and to substitute an artificial auricle, which can be worn upon a spectacle frame.

Cases of acquired atresia of the external auditory canal do admit of surgical interference, and will be discussed under the radical operation.

A deformity which is of interest to the general surgeon, is a condition known as **"prominent ears."** In this condition either one or both auricles stand away from the side of the head so as to cause considerable disfigurement. In the simpler cases the entire auricle is prominent.

In other instances the lower portion of the auricle may be attached to the head at a normal angle, while the upper portion curls over and droops forward, so as to present an unsightly deformity.

The *surgical correction* of each of these conditions is exceedingly simple. If the entire auricle is prominent, it is necessary to make two semilunar incisions through the integument—one just behind the line of auricular attachment, over the surface of the skull, and the other just in front of the line of auricular attachment, over the posterior surface of the auricle. These two crescentic incisions are joined at their upper and lower extremities and the integument included between them is dissected out. The skin is then loosened from the posterior surface of the auricle sufficiently to allow these two lines of incision to be coapted. This, of course, draws the ear closely to the side of the head and corrects the deformity. The amount of integument requiring excision will depend upon the degree of deformity. It is very seldom necessary to excise any cartilage in this class of cases.

If the deformity involves the upper part of the auricle alone, the crescentic incisions should be limited to the area of deformity. If the deformity is marked, it may be necessary to remove a certain amount of cartilage from the auricle, in order to correct the deformity. The procedure in either case is an exceedingly simple one, and is easily carried out.

The other deformities of the auricle, aside from microtia, do not deserve more than a passing notice. In certain cases supernumerary appendages are developed about the auricle, such as a supernumerary tragus. Such appendages are simply amputated, a semilunar incision being made on each side of the appendage, the appendage being cut off deeply in the wound. The margins of the incision are then brought together by sutures.

Another congenital malformation which perhaps may be mentioned is a **congenital aural fistula.** These fistulas are usually situated just below the anterior extremity of the helix or just above the tragus. The fistula is usually very shallow, but occasionally may extend inward for a considerable distance, and in some cases extends as far as the tympanic cavity. These fistulas represent an incomplete closure of the first visceral cleft during fetal life. They are of interest to the surgeon in that occasionally the orifice to the fistula becomes blocked, and a retention cyst may result.

Treatment.—The cyst should be freely opened and the wall of the fistula dissected out, the wound being closed, with or without drainage, as may be necessary. Complete dissection of the wall of the fistula results in a cure.

Diseases and Injuries of the Auricle.—The most common disease of the auricle which falls to the lot of the general surgeon is **perichondritis.** (See Fig. 441.) This is usually the result of traumatism, but may occasionally occur from exposure to intense cold. The disease is characterized by swelling of the entire auricle, this swelling being most marked upon the anterior surface. On palpation the parts are extremely sensitive, and fluctuation is easily elicited over the swollen area. In rare

instances the anterior surface of the auricle escapes, and the disease is limited to the tragus and antitragus.

Treatment.—In the early stages the application of cold may do some good. Usually, however, when the case is presented to the surgeon, more radical interference is necessary. This should consist in opening the fluctuating tumor freely by incision along its periphery. If the tumor fills the entire space in front of the helix, an incision should be made about the margin of the tumor just within the helix. The large flap should be turned downward and the contained fluid evacuated. Examination will generally reveal some necrotic cartilage. All necrotic cartilage should be dissected out and the flap then stitched back in place, a small drain of sterile gauze being inserted into the cavity and brought out at the most dependent portion of the incision. The stitches should be removed at the end of thirty-six to forty-eight hours, and at this time the drain may also be removed, provided the cavity is perfectly clean. Usually, however, the cavity will be found septic, and it will be necessary to keep the drain in position for a considerable time, re-inserting it at each dressing.

Fig 441.—Perichondritis of Auricle.

The results of operative interference in perichondritis are not very good. Considerable deformity of the auricle is apt to follow, but this deformity is much less in the cases operated upon early, and if all diseased cartilage is excised, than if the cases are subjected to any less radical plan of treatment.

Othematoma.—Othematoma, or a blood tumor of the auricle, was formerly supposed to be of idiopathic origin, and to be found almost entirely in individuals of impaired intellect. At present there is strong reason to believe that these cases are really traumatic, and should be classed as cases of perichondritis. The treatment is exactly the same as that already outlined for *perichondritis*—free exploration of the cavity, excision of any exposed cartilage, suture and drainage. (See Vol. II, page 795.)

Benign Tumors of the Auricle.—The benign tumors of the auricle scarcely require any mention. They may be either fibrous, lipomatous, or atheromatous. Sebaceous and simple cysts are found in this locality, and also various forms of papillomata.

The *treatment* of these conditions is excision, following the rules of general surgical procedure.

Exostoses of the External Auditory Meatus.—The most common

benign neoplasm affecting the external auditory meatus is exostosis. The etiology of exostoses is obscure. They are quite frequently found as a complication of chronic middle-ear suppuration, in which condition their presence can be explained as the result of an infection of the periosteum due to a discharge from the middle ear. Frequently, however, these growths occur in cases in which there is no history of middle-ear suppuration. Some have attributed them to a gouty diathesis, while their occurrence with great frequency among the inhabitants of tropical climates, especially among the Hawaiians, has led others to regard sea-bathing as a cause. From a practical point of view, nothing is known about their etiology. These growths may appear in any part of the external auditory canal. Their usual site, however, is the postero-superior wall of the meatus. They may vary in size from the head of an ordinary pin to a growth which completely blocks the external canal and completely hides the drum membrane from view. The growths may be either simple or multiple. Ordinarily, they are multiple, that is, there may be one exostosis upon the posterior wall of the canal, and a similar growth from the superior wall. The anterior and inferior walls are seldom invaded.

The growth may be situated either at the entrance of the bony meatus or close to the drum membrane. In some instances the growth extends from the entrance of the bony meatus as far as the fundus of the canal.

Treatment.—In the case of small growths no treatment is necessary. If the growth encroaches to a considerable extent upon the lumen of the meatus, its removal is necessary, for the reason that if acute otitis should occur in a case of this kind, it would be impossible to secure proper drainage by incision of the drum membrane. Moreover, if these growths are large enough to almost occlude the external auditory canal, they interfere somewhat with hearing. Exostoses are always best removed through a posterior incision. Some successful cases of removal through the external auditory canal have been reported, but this procedure is hazardous and unsurgical.

Operation.—The parts should be thoroughly shaved and sterilized for a distance of three inches about the meatus in every direction. The meatus should also be sterilized by mopping with an alcoholic solution of bichlorid of mercury, of a strength of 1:3000. An incision is made behind the ear, beginning at the tip of the mastoid and following the line of auricular attachment to a point just above the superior attachment of the auricle. This incision is carried through the periosteum, and the periosteum elevated anteriorly, so as to displace the auricle forward. The fibrocartilaginous meatus is then detached, by means of a narrow periosteum elevator, from the bony canal, thus allowing a complete inspection of the bony meatus through the posterior opening. Care should be taken to dissect off the tegumentary lining of the canal as completely as possible, without rupture of its lumen, the dissection being carried down as near to the drum membrane as possible. The anterior flap, including the auricle, is then drawn forward by means of a retractor, or a strip of gauze is threaded through the external auditory meatus, brought out through the posterior opening, and the auricle is drawn forward in this way. In

this manner the bony growths are brought clearly into view. If necessary, the posterior wall of the meatus may be split longitudinally. Under bright illumination, preferably by means either of the forehead mirror or the forehead headlight, the exact site of the growths can be made out. The bony tumors are then removed by means of a gouge. The growths should be removed entire; that is, the gouge should be carried through the healthy bone just beneath the base of the bony tumors. If an attempt is made to remove the tumor little by little, that is, to chisel the mass away, the result will usually be unsatisfactory, as these growths are extremely dense. If, however, the growth is removed *en masse*, by chiseling through the base of the growth, no difficulty will be experienced. Care must be taken, in removing growths close to the drum membrane, not to injure the membrana tympani, and where there is sufficient space, it is wise to introduce a strip of gauze into the fundus of the canal, between the exostosis and the membrana tympani, so as to prevent injury. After the growth or growths have been removed, the soft parts are replaced, a strip of gauze is packed firmly into the external auditory meatus, to hold the fibrocartilaginous meatus in position, and the posterior wound is closed completely by either interrupted or continuous suture. The results of the operation are uniformly satisfactory, and in my experience these growths never recur after removal.

Malignant Tumors of the Auricle and External Auditory Meatus.—Either epithelioma or sarcoma may attack the auricle and external auditory meatus. Epithelioma is usually of slow growth in the auricle. The sarcomata, on the other hand, grow more rapidly.

Treatment.—A beginning epithelioma of the auricle is best treated by means of either the *x*-ray or radium tube. If this plan of treatment fails, complete excision of the growth should be performed. In two cases which came under my observation the excision of a wedge-shaped piece of the auricle, with the subsequent suture of the parts, gave a perfect result, and no recurrence had followed at the end of several years. In extensive epithelioma, involving not only the auricle, but the external auditory meatus as well, complete excision should be performed. In the cases which have come under my observation lymphatic involvement has been very limited. In one case the entire auricle was amputated and the enlarged glands, which in this case were located along the posterior border of the sternomastoid muscle, were completely excised. The case was followed for at least four or five years after the operation, and there was no recurrence. In cases of sarcoma of the auricle early operation is advisable. In one case of melanotic sarcoma involving the anterior extremity of the helix and the adjacent tissues of the cheek complete excision gave relief for about two years. The growth then recurred, and was excised again. After the second operation there was no recurrence.

Deformities, Diseases, and Injuries of the External Auditory Meatus.—Regarding the deformities of the external auditory meatus, little need be said aside from what has already been mentioned under microtia. The congenital absence of the meatus has been noted as a

concomitant of this deformity. While operative interference has been undertaken for its relief, the results have not been satisfactory.

The acquired **atresias** of the meatus, complete or partial, following chronic suppuration, will be considered under the treatment of chronic suppurative otitis media. The radical operation here is the proper procedure and the prospects of improvement are exceedingly good.

Injuries of the external auditory canal may result either from direct traumatism to the canal or from blows on the head, causing a fracture through the external auditory meatus. Lesions of the canal from direct traumatism result ordinarily in a diffuse inflammation of the external auditory meatus. They should be treated along general surgical lines: irrigation of the canal, at frequent intervals, by means of warm antiseptic solutions, preferably a solution of bichlorid of mercury, of a strength of 1:6000, with deep free incision if the infiltration is extensive, will usually be found effective. After the parts have been incised the application of a wet dressing covering the entire ear will probably be followed by better results than will irrigation. In applying a wet dressing a strip of gauze moistened either in a 1:10,000 bichlorid solution or in normal saline solution should be inserted into the meatus and a wet dressing applied over the entire ear. This dressing should be changed twice daily.

The diseases of the external auditory meatus which interest the general surgeon are acute circumscribed and acute diffuse inflammation and neoplasms. The neoplasms have already been considered under neoplasms of the auricle.

Acute Circumscribed Otitis Externa or Furuncle.—This condition is always due to direct infection of the parts, either through a purulent discharge from the middle ear, or through the introduction of some infectious organism into the canal from without. The symptoms are first a feeling of stuffiness in the ear, rapidly followed by severe pain. This pain is increased by motion of the jaws, as in talking or in the mastication of food. Palpation about the auricle also elicits pain. The pain is usually most severe on pressing the tragus inward, but may also be elicited by pressing the lower border of the canal upward, or by taking hold of the auricle and moving it in various directions. There is seldom any marked rise in temperature, although the temperature may be slightly elevated. An examination of the ear without the speculum shows a narrowing at the entrance of the meatus. The introduction of the aural speculum is difficult and causes excruciating pain. If the disease has lasted for one or more days, the introduction of even the smallest speculum will be exceedingly painful and very difficult. After the speculum has been introduced, however, by careful manipulation, the deeper portion of the canal will be found entirely free from disease and the drum membrane normal in color. This localization of the swelling at the entrance of the meatus, the fundus of the canal being clear, and the tenderness on palpation about the auricle, makes the diagnosis positive.

It is sometimes difficult in the early stages, owing to the diffuse swelling, to locate the point of infection exactly. This is best done by palpating the margin of the meatus with a cotton-tipped probe. As the

probe makes pressure on the various aspects of the meatus, one or more points of excessive tenderness will be found. These points mark the areas of greatest infiltration.

Treatment.—Free incision through the points of greatest tenderness is the best treatment in these cases. Prior to making these incisions the parts should be sterilized as completely as possible by mopping the canal thoroughly with an alcoholic solution of bichlorid of mercury of a strength of 1:3000. This will sufficiently disinfect the field of operation. A deep incision should then be made in the long axis of the canal, through the points of greatest tenderness, these incisions extending not only through the skin, but through the subcutaneous tissue, and well down to the fibrocartilaginous framework of the canal. The operation is exceedingly painful, and the incisions are best made under nitrous oxid anesthesia, the tender points having been previously determined. After the incision a strip of sterile gauze, moistened either in bichlorid solution, of a strength of 1:10,000, or in normal salt solution, should be inserted into the canal, and a wet dressing applied over the entire ear. The dressing should be changed twice daily. Where the abscesses are large, it is well to insert a narrow strip of gauze into the opening made in each abscess, in order to secure perfect drainage. At the end of two or three days the wet dressing may be abandoned and the external auditory canal irrigated every three or four hours with a warm solution of bichlorid of mercury of a strength of 1:10,000. Irrigations should be practised until the parts resume their normal appearance. It is well to sterilize the entire canal at least once daily by mopping it out with an alcoholic solution of bichlorid of mercury of a strength of 1:3000, so as to prevent successive infections; in other words, to prevent a crop of furuncles.

It should be remembered that furunculosis attacks only the tissues about the entrance of the meatus. A furuncle never occurs in the bony canal, a circumscribed inflammation in the bony meatus being always indicative of trouble in the mastoid, as will be mentioned later. Severe complications of this disease are rare. Occasionally, however, if neglected, a furuncle may cause a perichondritis of the auricle, particularly of the tragus. The treatment of this condition has already been discussed under perichondritis, and consists in free excision of the diseased cartilage.

Another and very rare complication is direct extension to the mastoid periosteum, with subsequent involvement of the bone. This latter complication, however, is extremely rare.

Diffuse Inflammation of the External Auditory Meatus.—Instead of a circumscribed inflammatory process involving the canal, as in the condition just described, all of the tissues of the canal may participate in the inflammatory process and the entire fibrocartilaginous meatus be involved. The symptoms are exactly the same as those of acute circumscribed otitis externa, with the exception that they are more severe. The *treatment* is precisely the same as that of the other condition (free incision of the infected area, followed by dressing and subsequent irrigation).

Foreign Bodies in the External Auditory Canal.—The symptoms produced by foreign bodies in the external auditory canal vary with the

nature of the foreign body. Hard substances, such as bits of glass or pieces of metal, may enter the external auditory meatus either accidentally or may be introduced intentionally, and even though they remain in the canal for an indefinite period, may never give rise to symptoms. On the other hand, foreign substances, such as seeds, which increase in size as they absorb moisture, will give rise to symptoms of pressure as the volume of the foreign body increases.

The symptoms to which the foreign body gives rise may be divided into two classes: first, those which affect the function of the organ, and, second, general inflammatory symptoms. A foreign body large enough to occlude the external auditory meatus will cause an impairment of hearing and a feeling of fullness or stuffiness in the ear. If the foreign body does not completely occlude the meatus, it may remain in the canal for an indefinite period without causing any symptoms. The inflammatory symptoms are most frequently brought about by unsuccessful efforts at the removal of the foreign body. This brings us to the treatment of the condition.

The removal of a foreign body from the external auditory canal is most easily accomplished by means of a stream of water introduced by the aural syringe. Unless the foreign body lies at the very entrance of the meatus, no attempt should be made to remove it with instruments, such as the forceps, the curet, or blunt hooks. It will be remembered that the cartilaginous joins the bony canal at an obtuse angle. A foreign body introduced into the meatus generally lodges just external to this line of junction. If an attempt is made to remove the foreign body with the forceps or curet, it is very frequently crowded beyond this angle, and then further efforts at extraction crowd it still deeper into the meatus, toward the drum membrane. Extraction with instruments of this character should only be undertaken by one accustomed to manipulations of this sort, and then only under the best possible illumination. As before stated, syringing is the best method of removing any foreign body, and is the plan which should always be followed as a primary procedure. It is best to use an antiseptic solution for this purpose. An aqueous solution of 1:6000 bichlorid serves the purpose as well as any other. In using the aural syringe the fluid should be injected with a fair amount of force into the meatus, the stream being directed first along the posterior wall of the canal, then along the superior, next the anterior, and finally along the inferior wall of the canal. In this way the fluid will gradually work in between the drum membrane and the foreign body, and continued efforts at syringing will force the foreign body from the meatus.

In certain cases syringing will not remove the foreign body. In these cases it is much better to give the patient a general anesthetic, and attempt to remove the foreign body by means of the forceps or the curet, than to attempt the same manipulation while the patient is conscious. In the case of melon-seeds, peas, beans, or foreign bodies of this kind, it is sometimes possible, when the patient is anesthetized, to take out the soft interior of the foreign substance by means of the curet, and then subsequently to remove the shell with the forceps or with the curet.

Care must be taken in all manipulations, not to force the foreign body through the tympanic membrane into the middle ear, thus exciting an acute middle-ear inflammation.

If the foreign body cannot be extracted through the external auditory meatus, it will be necessary to remove it through a posterior incision. This operation is performed as follows: The parts about the ear are shaved for a distance of three inches in every direction from the center of the meatus, and thoroughly sterilized in the usual manner. The auricle is then drawn forward and an incision made along the line of auricular attachment, down to the bone. The periosteum is elevated so as to expose the margin of the bony canal and the cartilaginous canal is carefully dissected out from the bony canal by means of a blunt dissector. The fibrocartilaginous canal is split longitudinally and a strip of gauze is threaded through the meatus and brought out at the posterior opening, drawing the anterior flap, consisting of the auricle and fibrocartilaginous canal, well forward. This enables the surgeon to see the deeper portion of the meatus clearly, and also increases somewhat the diameter of the meatus, as its fibrocartilaginous lining has been dissected out. If sufficient space is not obtained in this way to remove the foreign body, the meatus should be enlarged along its posterior aspect by chisels until the requisite amount of space is obtained for the extraction of the foreign body. After thoroughly wiping the parts with sterile sponges, the fibrocartilaginous canal is allowed to drop back into position, and a packing of sterile gauze is placed in the external auditory meatus, so as to hold the fibrocartilaginous canal in its proper place. The posterior wound is completely closed by means of sutures and an ordinary dressing of sterile gauze applied. Recovery in these cases is uneventful.

Injuries of the Membrana Tympani.—The drum membrane may be ruptured either by instruments introduced into the external auditory meatus or by sudden condensation of air in the meatus, as from a blow upon the ear either by the hand or, as sometimes happens, in sea-bathing, by the impact of a wave. Very loud sounds, such as the firing of heavy pieces of artillery, may rupture the membrane. In children the drum membrane may also be ruptured by direct traction upon the auricle. Chemical irritants introduced into the canal may also cause a perforation of the drum membrane.

The cases which most interest the general surgeon are those in which a rupture of the *membrana tympani* occurs as the result of a blow upon the head, causing a fracture of the base of the skull. Here the traumatism may occur either in the region of the ear or, in certain instances, a rupture of the drum membrane may be caused by a fall upon the vertex, causing a fracture of the base.

Symptoms.—The first symptom of rupture of the drum membrane is a sanguinolent or sero-sanguinolent discharge from the ear. If the rupture occurs as the result of direct violence to the drum membrane, there is usually severe pain in the ear. In cases in which the rupture of the membrana tympani is symptomatic of a fracture at the base of the skull, there is apt to be very little pain, this being masked by the graver

symptoms of the accident. The discharge from the ear, however, is usually large in quantity, and from being sero-sanguinolent, quickly becomes serous. A persistent discharge of clear serum from the ear, following an injury to the head, is indicative of a fracture through the petrous portion of the temporal bone, permitting of the escape of labyrinthine and subarachnoid fluid.

In injuries to the skull, when the discharge is small in quantity, and simply blood, there is probably rupture of the drum membrane, without any fracture through the petrous portion of the temporal. Whenever the drum membrane is ruptured, infection of the middle ear may take place, and the sanguinolent or sero-sanguinolent discharge be followed by a purulent discharge, owing to secondary infection of the middle ear.

Treatment.—In all cases the first object of treatment should be to secure perfect asepsis of the canal. This is best conserved by frequent irrigation of the ear by means of an antiseptic solution, preferably one of bichlorid of mercury of a strength of 1:6000. This irrigation should be repeated every two hours while the discharge remains profuse, and as the discharge diminishes in quantity the frequency of irrigation should be lessened. The quantity of fluid used at each irrigation should be about half a pint. The ear should be carefully examined by means of the speculum, so as to determine the extent of injury. In cases in which a linear rupture of the drum membrane has occurred, and in which the discharge ceases in the course of a few days, it is well to attempt to repair the injury by first sterilizing the parts by mopping the canal and the surface of the drum membrane with an alcoholic solution of bichlorid of mercury of a strength of 1:3000, and then applying a disc of sterilized paper to the surface of the drum membrane, so as to completely cover the line of rupture. This prevents subsequent infection of the middle ear and also promotes the rapid healing of the injured membrana tympani without the development of much cicatricial tissue.

If the rupture is extensive, this plan of treatment cannot be carried out, and irrigation should be continued until the wound in the membrana tympani heals completely.

Aside from rupture of the tympanic membrane, the other diseases of this structure belong more to works on special surgery, and the reader is referred to these works for a more extended discussion of this subject.

Diseases of the Middle Ear.—Acute Inflammation of the Middle Ear.—The milder inflammations of the tympanic cavity do not interest the general surgeon. Both the acute and chronic suppurations of the middle ear, however, come very properly within his province. An acute inflammation of the middle ear or an acute otitis media, in an adult, is almost always characterized by severe pain referred to the ear. In young children, however, pain may be absent, and the only indication which we have of acute middle-ear suppuration may be a sudden elevation of temperature. Acute otitis media may occur idiopathically, or more usually as a complicating lesion of one of the acute infectious diseases. Grippe is undoubtedly the most common exciting cause. The other acute infectious diseases, such as measles, scarlet fever, and diphtheria,

may cause the condition, in the order stated. The condition is frequently produced by the insufflation of water into the nose, either in bathing or during the use of the nasal douche. In the adult the clinical history is usually clear. Ordinarily, there is a previous history of some congestion of the upper air-tract—either an acute cold in the head, an acute attack of grippe, or one of the acute infectious diseases previously mentioned. The pain in the ear comes on rather suddenly, and increases in severity. The temperature is ordinarily elevated one or two degrees. The only conditions which can be confounded with acute otitis in adult life are furuncle in the external auditory canal and the reflex pain in the ear, due to either an inflammation of the tonsils, malignant disease of the larynx, or a carious tooth. All of these reflex conditions can be excluded by proper physical examination.

As a rare symptom of an acute inflammation of the middle ear we should mention facial paralysis. While facial paralysis is an uncommon complication of inflammation of the middle ear, it occasionally occurs, in both infancy and adult life. This symptom is not necessarily due to necrosis of the Fallopian canal, as was formerly supposed. We know that, under normal conditions, large dehiscences sometimes occur in the Fallopian canal, and where this condition exists, an acute inflammation within the tympanic cavity may cause a facial paralysis. In fact, I have seen a number of cases of facial paralysis due to a very mild inflammation of the middle ear. Facial paralysis, coming on late in an attack of acute otitis media, is of greater significance than where this symptom occurs early in the disease, and it may be given as a general rule that the later the symptom occurs, the more radical should be the operative interference. This condition will be spoken of more in detail in considering the operative treatment of mastoiditis.

A physical examination of the ear, in a case of acute otitis, shows a marked reddening of the membrana tympani. According as the upper or lower part of the tympanic cavity is involved, this change in color will involve the upper portion of the tympanic membrane, or Shrapnell's membrane, or the lower portion of the membrana tympani or the membrana tensa. Very soon after the beginning of the attack the membrane will be noticed to bulge into the external auditory canal. This bulging, in the case of suppuration within the tympanic vault, involves the upper portion of the membrana tympani. In inflammations of the lower portion of the cavity the posterior portion of the drum membrane alone appears to be bulging. In certain instances, in place of the intense redness of the membrana tympani usually seen in acute inflammations, the surface of the membrane may be white and lusterless, owing to necrosis of the superficial epithelium. When this epithelium is wiped away by means of the cotton-tipped applicator, the red color of the drum membrane characteristic of an acute inflammation of the middle ear will be observed. Palpation about the ear in adults elicits no pain in acute inflammations of the middle ear.

When we come to consider acute inflammations of the middle ear in children, the only general symptom may be a sudden and unexplained

rise in temperature. The temperature in these cases is often very high, and in the early stages of the disease may rise to 104° or 105°. The surgeon should make it a rule, in all cases of unexplained elevation of temperature in children, to examine the ears, and this is especially true in all cases where there is a sudden rise of temperature complicating one of the acute infectious diseases in childhood, especially one of the exanthemata. Here a sudden rise in temperature is almost always due to an involvement of the tympanic cavity. While restlessness or sleeplessness is sometimes characteristic of this condition in children, in quite a large proportion of cases the child shows no evidences of any pain. These children may sleep perfectly well at night and, aside from a rise in temperature, may present absolutely no deviation from the normal standard. In children palpation about the ear usually elicits pain, especially pressure in front of the tragus. As stated earlier in this chapter, the bony canal is entirely wanting at birth, and the inferior wall of the meatus at the fundus lies in contact with the drum membrane. It can easily be seen, therefore, that pressure in front of the tragus will press the drum membrane inward, and will therefore cause pain in case of an inflammation of the middle ear. The signs on speculum examination are exactly the same as those detailed in the description of the disease in adults. It should be remembered, in examining children with the speculum, that the drum membrane occupies apparently a more horizontal position in infancy than in adult life, and that it is necessary to draw the auricle downward, backward, and outward, in order to separate the lower wall of the meatus from the upper wall, so that a clear and distinct view of the membrana tympani may be obtained.

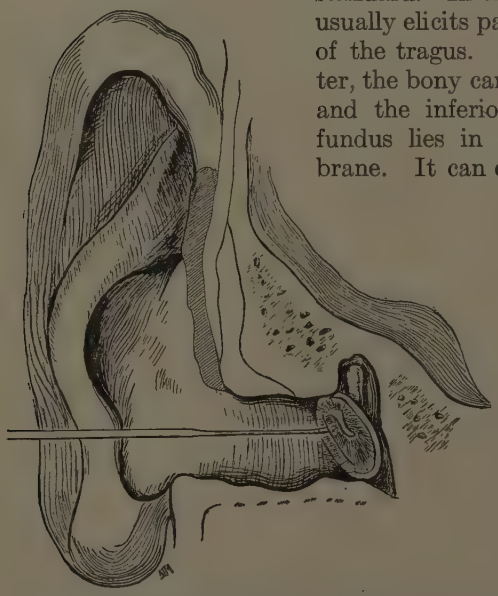

FIG. 442.—INCISION OF MEMBRANA TYMPANI IN ACUTE OTITIS MEDIA, INVOLVING LOWER PORTION OF TYMPANIC CAVITY.

Treatment.—In every case of an acute inflammation of the middle ear a free incision should be made through the drum membrane. Previous to the operation the parts should be thoroughly sterilized by mopping out the canal with an alcoholic solution of bichlorid of mercury of a strength of 1: 3000. All instruments used should be sterilized by boiling. The hands of the operator should also be sterilized, as for any operation. Incision of the drum membrane is an exceedingly painful operation, and should always be performed under general anesthesia, except possibly in the case of very young infants. In adults nitrous oxid is the best

anesthetic, while in young children chloroform is preferable. Particular attention is called to the term "incision of the drum membrane." Formerly "paracentesis" of the membrana tympani was advised. Paracentesis is an operation devoid of value, and in every case where it is necessary to open the tympanic cavity artificially, a free incision should be made through the membrana tympani. This incision should be made in the posterior segment of the membrane, and should extend from the inferior pole, upward along the posterior periphery of the membrane as far as the tympanic vault. (See Fig. 442.)

If the upper portion of the middle ear alone is involved, that is, if the inflammation involves the tympanic vault alone, the knife should first be thrust through the most prominent portion of the tumefaction, and the incision should be carried upward as far as the superior wall of the canal. The edge of the knife should then be turned backward, the point being directed upward and inward so as to enter the tympanic vault. During the withdrawal of the knife, the point of the instrument should be held in contact with the bony structures, so as to incise not only the upper portion of the membrana tympani, but all of the soft tissues of the posterior wall of the meatus as well, for a distance outward of at least an eighth of an inch from the drum membrane. This incision along the posterior wall of the canal serves to relieve tension within the tympanic vault and mastoid, and will frequently prevent serious mastoid involvement in cases of inflammation of the tympanic vault. (See Fig. 443.)

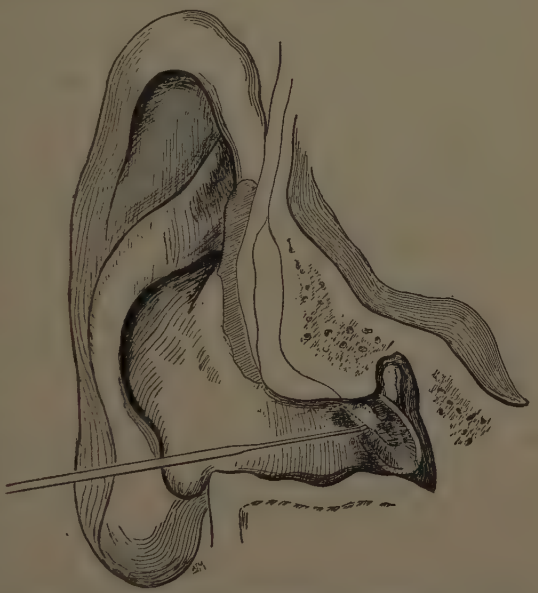

FIG. 443.—INCISION OF MEMBRANA TYMPANI IN ACUTE OTITIS MEDIA, INVOLVING UPPER PORTION OF TYMPANIC CAVITY.

After incision frequent irrigation of the external auditory canal should be performed. This is best accomplished with the small bulb syringe. A warm antiseptic solution should be used, preferably one of bichlorid of mercury of a strength of 1: 6000. The irrigations should be repeated every two hours during the day and every four hours during the night, about eight ounces of fluid being used at each irrigation.

This method of treatment is much to be preferred to drainage by means of sterile gauze inserted into the canal. As the discharge diminishes in quantity, the frequency of irrigation should also be diminished. It is

wise for the surgeon to see these cases at least once daily during the acute attack, and to sterilize the canal himself at each visit, by mopping it out thoroughly with an alcoholic solution of bichlorid of mercury of a strength of 1: 3000.

In certain cases of acute inflammation of the middle ear the discharge appears before the case comes under the observation of the surgeon. In cases where the perforation is competent and the drainage free, as evidenced in adults by a total absence of pain, and in children by little or no elevation of temperature, irrigation is the only treatment to be pursued. In most cases in which spontaneous perforation occurs, however, the perforation is so small as to give only imperfect drainage. In these cases free incision of the drum membrane, according to the rules already laid down, should be performed in order to secure absolutely free drainage. This incision is particularly indicated in children suffering from acute otitis, in whom, in spite of free discharge, the temperature still remains somewhat elevated.

Nothing has been said in the preceding pages in regard to the abortive treatment of acute otitis. While a very small proportion of these cases could possibly be aborted by early inflation of the middle ear, these cases are scarcely severe enough to come under the observation of the surgeon. All attempts at aborting the inflammation by means of local blood-letting, the application of heat or cold, and so forth, are unworthy of mention.

A word should be said in regard to the instillation of substances into the external auditory meatus for the relief of pain. Acute otitis is a surgical disease, and should be treated surgically. The instillation of any substance into the canal for the relief of pain is worse than useless, and tends to aggravate rather than to relieve the condition.

Chronic Suppuration of the Middle Ear.—Chronic middle-ear suppuration is the result of neglected acute suppuration. This is invariably true if we except those rare cases of tuberculous origin in which the suppuration comes on without any acute symptoms, and in which the first sign of disease is a discharge from the external auditory meatus. These cases are, however, comparatively infrequent, and a chronic discharge from the tympanic cavity should practically always be looked upon as the result of a neglected acute process.

The most characteristic symptom is a purulent discharge from the external auditory meatus. It may be stated as a rule, to which there are seldom any exceptions, that whenever a purulent discharge in the external auditory canal has been present for more than two or three weeks, this discharge comes from the tympanic cavity. Aside from those rare cases of neoplasm of the external auditory meatus, there is no condition of the external auditory canal which will give rise to a continued profuse purulent discharge, and hence the presence of such a discharge must depend upon suppuration within the middle ear.

The effect of this condition upon the function of the organ does not interest the general surgeon. It is only necessary to say that in these cases we are apt to have considerable impairment of hearing, although

in certain instances the hearing is only slightly impaired. A symptom of which these patients occasionally complain, and which should always excite attention, is vertigo. Dizziness, either constant or intermittent, associated with a discharge from the middle ear, always demands careful investigation, and is usually only relieved by surgical interference. The appearance observed in these cases on speculum examination varies widely. Only a passing reference can be made to the various pictures which are well illustrated in Figs. 444 to 449.

Fig. 444.—Chronic Purulent Otitis Media (Dench).

Extensive destruction of the membrana vibrans.

All the perforations which are found in these chronic conditions may be briefly classed under these six heads:

First, extensive loss of the lower portion of drum membrane, the perforation being more or less kidney-shaped, the narrow portion of the perforation corresponding to the long process of the malleus (Fig. 444).

Second, the same perforation, with the presence of granulation tissue developing in the tympanic cavity (Fig. 445).

Third, the anterior portion of the drum membrane intact, the upper and posterior portion destroyed, and a sinus leading upward into the tympanic vault (Fig. 446).

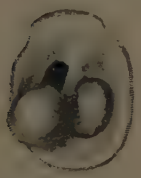

Fig. 445.—Chronic Purulent Otitis Media (Dench).

Exuberant granulation tissue developing within the tympanum.

Fourth, the membrana vibrans intact, but a perforation above the short process of the malleus. Granulation tissue may or may not be present in the perforation (Fig. 447).

Fifth, complete destruction of the membrana tympani, with displacement of the ossicles (Fig. 448).

Sixth, small perforation in the posterior portion of membrana tympani (Fig. 449).

Of these six pictures, the first and last may yield to milder measures. In the first instance there is a considerable destruction of the lower portion of the drum membrane, without granulation tissue, and simple cleansing of the ear by means of irrigation with antiseptic solutions, in the manner described under acute otitis, may cause a complete cessation of the discharge.

Fig. 446.—Chronic Purulent Otitis Media (Dench).

Membrana tympani adherent along inferior margin of perforation.

While the drum membrane is seldom restored in cases of extensive perforation, the internal wall of the middle ear may dermatize, and the ear remain dry indefinitely. This condition occurs most frequently in adolescents, and in these cases we usually have a history of recurrent attacks of otorrhea following severe colds in the head. Here attention not only to the ear, but to the upper air-tract, the removal of adenoid vegetations and of enlarged tonsils, together with irrigation of the ear, will sometimes bring about a complete and permanent cessation of discharge.

In a case in which there is a small perforation in the posterior portion

of the membrana vibrans (the cases designated under sixth in the above list) a free incision of the drum membrane, so as to secure perfect drainage, followed by irrigation of the ear and proper attention to the upper air-tract, will quite frequently bring about a complete cure, with closure of the perforation.

FIG. 447.—PERFORATION ABOVE THE SHORT PROCESS OF THE MALLEUS (Dench).

In all of the other conditions enumerated surgical interference will almost always be necessary, in order to secure a permanent cessation of discharge. I make this statement after a rather extensive experience, and after employing various methods of tentative treatment.

While this description of suppurative otitis may seem brief, the treatment outlined covers those measures which would ordinarily be applied by the general surgeon, and experience has shown that in the other conditions operation is almost invariably demanded sooner or later.

Particular attention is called to cases of intermittent discharge from the ear, and also to those cases in which the discharge is very slight. Both of these conditions are among the most serious with which we have to deal. Patients usually seek relief from a profuse aural discharge on account of the annoyance which a profuse discharge occasions. If, however, this discharge is intermittent, or if it is only slight, patients frequently fail to come under the observation of the surgeon until the middle-ear suppuration has caused intracranial infection.

FIG. 448.—CHRONIC PURULENT OTITIS MEDIA. OSSICLES DISPLACED (Dench).

Particular attention should be called to those cases in which a perforation exists in the posterior portion of the membrana tympani. In such cases the discharge is usually very slight; so slight, in fact, that it often forms a crust on the upper and posterior wall of the canal, and may be mistaken for cerumen. Examination will show perforation in the region named, with a sinus leading into the upper portion of the tympanic cavity. The discharge is always foul-smelling, and a careful examination with the probe will frequently reveal exposed bone in the tympanic vault. These cases almost invariably demand radical surgical interference, and the same may be said of cases in which granulation tissue is present (Fig. 445), and in which there is complete destruction of the membrana tympani, with displacement of the ossicles, as shown in Fig. 448.

FIG. 449.—CHRONIC PURULENT OTITIS MEDIA (Dench). Small perforation behind the umbo.

A condition invariably demanding surgical interference is one in which a perforation is present above the short process of the malleus. Through this perforation a probe can be passed into the tympanic vault, and a perforation in this situation is always indicative of caries in the tympanic cavity.

A chronic suppuration within the tympanic cavity frequently leads

to the development of a cholesteatoma. A cholesteatoma consists of a conglomeration of epithelial cells superimposed upon one another so as to form a firm, compact mass, containing, in addition to the epithelial cells, a certain amount of cholesterin. When dry, this foreign body causes but few symptoms. Owing to recurrent attacks of congestion of the tympanic cavity, however, this epithelial deposit becomes moistened from time to time, increases in size, and causes symptoms due to pressure. In the first place, by its increase in size it obstructs drainage from the upper portion of the tympanic cavity; secondly, it may cause severe pain; and, third, by continual additions to this mass, gradual destruction of the walls of the tympanic vault and mastoid antrum may occur. In extreme cases these cholesteatomata may be as large as a pigeon's egg, and may have caused destruction of all of the bony walls of the mastoid process and of the tympanic vault. In one case of cholesteatoma which came under my observation the outer wall of the mastoid was reduced to a thin shell; the internal wall was wanting over the floor of the middle cranial fossa, and posteriorly, over a portion of the cerebellar fossa, while the external wall of the tympanic vault and the posterior wall of the external auditory canal had been reduced to a very thin shell of bone.

The subject of the surgical treatment of intratympanic caries is a large one. Dead bone in the tympanic cavity offers a constant menace to life on account of the danger of intracranial infection. A middle-ear suppuration, therefore, should never be allowed to continue, and if it cannot be checked by the milder measures, detailed in the preceding pages, operative interference becomes imperative. The choice of the procedure must naturally vary in different cases. The simpler operation of ossiculectomy, that is, the removal of the ossicles through the external auditory meatus, with curetment of the tympanic vault through the canal, will not be considered in this article. Such procedures, if they are indicated, fall to the special surgeon. Although formerly an earnest advocate of this operation,[1] at present I believe its utility is restricted to a very small proportion of cases. I have kept under observation for many years cases previously operated on. A certain proportion of them remain well. In many instances, however, it has been necessary later to subject the patients to the radical operation, and this operation, I feel convinced at the present time, with our improved technic, is the one operation which should be performed in cases of chronic middle-ear suppuration. The description of this operation will be found under Radical Operation for Chronic Middle-Ear Suppuration. (See p. 832.)

Regarding the complications of chronic middle-ear suppuration, the intracranial complications will be described in a separate portion devoted to this subject. Among the unclassified sequelæ which may complicate a chronic middle-ear suppuration may be mentioned partial or complete facial paralysis, due to involvement of the facial nerve as it runs through the aqueductus Fallopii or through the mastoid process, and also chronic inflammation of the external auditory meatus, causing, in some cases, almost complete stenosis of the external auditory canal. If either of these conditions is present, surgical interference must be under-

taken, and the radical operation, which will be described later, constitutes the best method for relieving them.

Diseases of the Mastoid Process.—Acute inflammation of the mastoid usually follows either an acute or a chronic inflammation of the middle ear. While primary mastoiditis may occur, the condition is so uncommon as to deserve mention only as a pathologic curiosity. A primary involvement of the mastoid may occur rarely idiopathically, but more commonly as the result of a syphilitic or tuberculous infection. In tuberculous mastoiditis the middle ear is almost always involved. Quite a large proportion of the cases of mastoiditis follow acute inflammation of the middle ear, although if an acute inflammation of the middle ear is seen early and treated promptly, mastoid involvement can usually be prevented. In nearly a thousand operative cases of acute and chronic suppuration of the mastoid process which have come under my observation, I can recall only a very few cases in which mastoiditis occurred, when the acute middle-ear condition had been treated within twenty-four hours of its inception.

Among the other causes of mastoiditis we should mention, as idiopathic factors, acute inflammation of the external auditory meatus. While it is very rare for an inflammation of the external auditory canal to secondarily involve the mastoid process, this condition does occur, and should be borne in mind.

Symptoms.—The symptoms of acute inflammation of the mastoid vary exceedingly. In a typical case, following acute otitis media, or in those cases in which acute mastoiditis is grafted upon a previous chronic middle-ear suppuration, the first symptom is usually pain, referred to the region of the ear and to the mastoid process. In cases complicating acute otitis media the pain in the mastoid usually comes on several days after the inception of the acute otitis, and, if the case has been treated according to the rules already laid down, generally after the acute pain in the ear has temporarily subsided. A typical history following acute otitis media would be somewhat as follows: The middle-ear inflammation would be characterized by its regular symptoms of pain in the ear, with some increase in temperature. This would be relieved by incision of the drum membrane, and a profuse discharge from the middle ear would follow. In the course of a few days this discharge would become scanty, and the patient, who had been free from pain since the incision of the drum membrane, would begin to complain of severe pain in the ear and also in the mastoid process. Occasionally this discomfort does not amount to severe pain, and may simply keep the patient awake at night, the patient complaining of no particular pain, but simply saying that he cannot sleep. Coincident with this pain there may or may not be an elevation of temperature. I have seen a number of cases in which careful temperature observations have been kept in which the pain has been severe, and other cases in which, without severe pain, there has been sleeplessness, and yet careful observations have failed to reveal any rise in temperature.

Another symptom of importance is that referable to the aural discharge. The discharge from the ear usually diminishes in quantity as

the mastoid symptoms begin to declare themselves. In other words, there is deficient drainage from the middle ear, and consequent involvement of the mastoid process. As before stated, the temperature may or may not be elevated. I wish to emphasize this point particularly, because in some severe cases we have no elevation of temperature. This usually applies to acute mastoiditis in adults. In children, there is usually some elevation of temperature in these cases. While a diminution of the discharge is usually characteristic of involvement of the mastoid process, there are certain cases in which the discharge is increased in quantity. In them the symptoms are less acute. The patient does not complain of pain, as a rule, but the acute inflammation of the middle ear simply fails to clear up under the usual local treatment, and the discharge from the ear, instead of diminishing in quantity, becomes more and more profuse. This condition is not infrequently found in children. The persistence of the profuse purulent discharge from the external auditory meatus for a number of weeks following an attack of acute otitis should always make the surgeon suspicious of an inflammation of the mastoid process. In other words, the middle ear is a cavity of comparatively small size, and while an acute inflammation of the middle ear may cause a profuse otorrhea for a number of days, or even for one or two weeks, if the disease is limited to the middle ear this discharge should certainly diminish at the end of two weeks. If, on the other hand, the discharge still remains profuse, even although the patient complains of no severe pain, the continuation of the profuse discharge should be looked upon with suspicion. This is particularly true in the case of children.

Quite recently much has been written as to the value of a differential blood count in determining the advisability of operation in these cases. While I do not wish to underrate the value of a careful blood examination in all cases, I can only say that in my own experience—and these examinations have been invariably made in my cases—a differential blood count has been of very little value in the matter of determining the necessity of operation. In a certain small proportion of cases a high polymorphonuclear percentage, as compared with the total leukocytosis, has been found. In a very large number of cases, however, this relative increase in polymorphonuclear cells has not appeared, and in some cases in which there has been almost complete destruction of the mastoid process by suppuration, the percentage of the polymorphonuclear cells has not risen above the normal standard, and in no instance in doubtful cases has it reached 80 per cent. While I believe, then, that the blood count is of some value in determining the presence of suppuration in the mastoid, I do not believe that it can be relied upon in the majority of cases.

When we come to consider the special signs indicative of mastoid involvement, a careful examination will ordinarily enable the surgeon to determine, with absolute accuracy, whether or not the mastoid is involved, and by this I mean whether operative interference is necessary. First among the signs upon examination should be enumerated local tenderness. Tenderness on palpation over the mastoid process is an almost certain sign of mastoid involvement if there has been involvement

of the middle ear for any considerable time. Mastoid tenderness may be present either over the antrum, over the tip of the mastoid, or just behind and above the mastoid tip, near the point of entrance of the mastoid emissary vein. Mastoid tenderness is elicited by firm pressure with the index-finger or thumb over the mastoid, care being taken in this manipulation not to move the auricle. If pressure is made upon the bone only, and no motion is communicated to the auricle, mastoid tenderness is a very significant sign. To avoid communicating any motion to the auricle, the palpating finger or thumb should be pressed upon the mastoid just behind the line of auricular attachment and firm pressure be made backward and inward. In this manner the pressure is brought directly upon the mastoid itself, while no motion is communicated to the auricle or fibrocartilaginous canal. If any pressure is used forward along the line of auricular attachment, movement is communicated to the auricle and fibrocartilaginous canal, an error in diagnosis may arise. A furuncle on the posterior wall of the external auditory meatus, or, in fact, anywhere in the external auditory meatus, will cause tenderness on pressure over the mastoid if, at the same time, the auricle is crowded forward so as to communicate this motion to the meatus. Care must be exercised, therefore, in palpating the mastoid process, to see that the mastoid alone is palpated, and that the canal and the auricle are not moved. Tenderness over the mastoid tip is usually less significant than tenderness over the mastoid antrum. Although the mastoid antrum is much more intimately related to the middle ear than are the cells at the mastoid tip, it is a common clinical experience to find tip tenderness early in numerous cases of acute middle-ear inflammation. This tip tenderness usually disappears in the course of a few days and, occurring early in a case of acute otitis, is of no special significance. On the other hand, tenderness over the mastoid antrum, either at the beginning of the attack or coming on a few days after an attack of otitis, is an exceedingly significant symptom, as is also tenderness over the antrum following a preceding tip tenderness. Tenderness behind and above the mastoid tip is significant, but should not be mistaken for the tenderness occurring in occipital neuralgia. Under normal conditions a tender point is found behind and above the mastoid tip, corresponding to the point of emergence of the occipitalis major nerve, and this should never be mistaken for tip tenderness. A comparison of the tenderness upon the two sides, if one side alone is involved, will be sufficient to prevent an error in diagnosis from this cause.

The next most constant sign of mastoid involvement is the evidence presented on speculum examination. In speaking of the anatomy of the middle ear, attention was called to the fact that the upper wall of the external meatus, close to the drum membrane, constitutes the floor of the aditus ad antrum. Consequently, when an inflammatory process extends from the middle ear to the mastoid, one of the earliest signs which we have is a sinking of the upper and posterior wall of the external auditory meatus, close to the drum membrane. This narrowing of the vertical diameter of the deep canal is probably the most significant sign of mastoiditis. On speculum examination the upper and posterior wall of

the external auditory meatus sinks downward and forward so that the vertical diameter of the canal is diminished and the fundus in its vertical dimension is narrowed; in other words, the fundus appears less broad from above downward than normally. The line of demarcation between the drum membrane and the external auditory meatus also fades away, so that the postero-superior wall of the canal seems to pass, without any line of demarcation, into the drum membrane, and the fundus of the canal appears conical rather than circular.

The two signs, then, of local tenderness and sinking of the upper and posterior wall of the canal, are the signs to be relied upon in determining mastoid involvement.

I have spoken of those cases complicating acute otitis. The signs and symptoms of mastoid involvement, following an acute exacerbation in a chronic suppurative otitis media, are exactly the same as those complicating an acute middle-ear inflammation. I have purposely said nothing about redness behind the ear, or the presence of a post-aural fluctuating tumor. In cases seen early, the surgeon never waits until there is edema over the mastoid, or until there is a subperiosteal abscess, before making his diagnosis. It should be remembered that post-aural edema is rather more significant of inflammation of the external auditory meatus—that is, of a furuncle on the posterior wall of the external auditory canal—than it is of a mastoiditis. The rules laid down regarding the proper palpation of the mastoid will enable the observer to make a differential diagnosis. In cases seen late, and in which rupture through the mastoid cortex has occurred, a fluctuating post-aural swelling may be found. In early infancy involvement of the mastoid may be so rapid and so insidious as to cause extensive mastoid involvement, with the presence of a post-aural fluctuating tumor as the first symptom of the disease. If the mastoid is involved and the inflammatory products are evacuated spontaneously, rupture through the bony cortex may take place in one of four situations: First, through the mastoid cortex, over the region of the antrum; second, through the mastoid tip into the digastric fossa, beneath the sternomastoid muscle; third, through the anterior surface of the mastoid, causing tumefaction of the posterior wall of the external auditory canal; and, fourth, at the root of the zygoma. These points of rupture are mentioned in their order of frequency.

Treatment.—The treatment of acute mastoiditis is always operative. The condition can only be relieved by the evacuation of the inflammatory products. Whether this evacuation is secured through the external auditory meatus by a free incision of the drum membrane, or whether it is secured by operation upon the mastoid itself, will depend upon the severity of the symptoms. In cases of acute middle-ear inflammation, followed by spontaneous rupture of the drum membrane and insufficient drainage, if these cases are seen with beginning mastoid tenderness, the surgeon may attempt to secure drainage by a free incision through the drum membrane. This incision should freely drain the tympanic vault, and should be extended outward on to the supero-posterior wall of the canal, as described under the treatment of acute purulent otitis media. In

cases in which incision of the drum membrane has been performed early, and symptoms of mastoid involvement supervene after free incision of the drum membrane, I do not believe it is wise to attempt to abort the disease by a second incision through the membrana tympani. Ordinarily, a second incision of the drum membrane simply serves to relieve the symptoms for a few days, and on opening the mastoid we find suppuration within the bone so far advanced as to prove the utter futility of the milder efforts to relieve the condition.

Regarding other tentative measures, such as local blood-letting, and the application of the ice-coil, a rather extensive experience has convinced me that both these methods are absolutely worthless. Formerly, in acute mastoiditis, it was customary to apply cold continuously to the mastoid, either by means of the Leiter coil or by means of the ice-bag, for a period of at least thirty-six hours, in order to abort the inflammatory process. After a very careful use of this method I can freely say that I have never seen the least benefit result from it. Cold simply masks the mastoid symptoms, and while relieving the signs of superficial inflammation, allows the process to extend more and more deeply into the bone. For this reason, therefore, I am opposed to the local application of cold. It goes without saying that internal medication for the relief of the pain is absolutely dangerous. It simply serves to mask the symptoms.

It is difficult to decide when to operate upon any given case. I have seen cases of acute otitis which developed mastoid symptoms demanding operation within forty-eight hours after the acute otitis began. In any case if the pain is severe and unrelieved by free drainage after incision of the drum membrane, if mastoid tenderness persists in spite of such free drainage, especially if there is any elevation of temperature, an immediate operation should be performed. Added to these symptoms there is the sinking of the upper and posterior wall of the bony canal close to the membrana tympani. If either tenderness or the physical sign of sinking of the upper and posterior canal wall should be absent, and yet the pain in the ear be severe, with an elevation of temperature, I should be inclined to operate early in any given case. Ordinarily mastoid involvement does not produce symptoms demanding operation before the fourth or fifth day after middle-ear involvement, granted that drainage through the external auditory canal has been established early. In cases in which free drainage through the canal is present after incision, a certain amount of mastoid tenderness may be disregarded for one or two days after the beginning of the primary attack, unless constitutional symptoms are present which seem to demand early operation. Cases in which spontaneous rupture of the drum membrane has occurred, and which present mastoid symptoms, will ordinarily demand operation much earlier than those cases presenting the same symptoms when free drainage has been secured by incision.

Mastoid Operation.—A few points in regard to the anatomy of the mastoid may not be out of place in this connection. Remembering that the mastoid antrum is the one pneumatic space which is always constant, and which really forms a part of the middle ear, and also that

drainage of the middle ear through a posterior opening is the result aimed at in all mastoid operations, it is evident that the mastoid antrum is the one pneumatic space which must be reached by operation.

The mastoid antrum is best located by drawing two tangent lines—one horizontal line tangent to the superior wall of the bony meatus, and the other a vertical line, tangent to the posterior wall of the bony meatus. The point of intersection of these two lines forms the apex of a triangle. The base of this triangle is formed by the curvilinear outline of the bony meatus inclosed between these two tangent lines. This triangle marks the aditus ad antrum, that is, the narrow passage joining the mastoid antrum and the tympanic cavity. In order to drain the middle ear, then, through a posterior opening, the deepest part of the opening in the bone must lie within this triangle.

In performing the mastoid operation we must remember the relation certain intracranial structures bear to the mastoid and middle ear. The roof of the mastoid antrum and tympanum form the floor of the middle cranial fossa. While ordinarily the tegmen tympani et antri is considerably higher than the superior wall of the external auditory canal, occasionally the middle cranial fossa is exceedingly low and encroaches upon the superior wall of the meatus, so that a horizontal plane passing through the roof of antrum and tympanum would actually enter the middle cranial fossa. This occasional low position of the middle cranial fossa must always be borne in mind in operating upon the mastoid.

It will also be remembered that the lateral sinus passes through the mastoid process. Under normal conditions the sigmoid portion of the lateral sinus is situated at a sufficient distance behind the posterior wall of the external auditory meatus to permit of a free exploration of the mastoid and free drainage of the tympanic cavity through the mastoid, without exposure of the sinus. Ordinarily, the descending portion of the sigmoid sinus lies at a distance of about half an inch behind the posterior margin of the bony meatus. Sometimes it is removed even further backward than this. Occasionally, however, the sinus projects well forward, and in two instances I have seen the sinus in actual contact with the posterior wall of the external auditory canal, while in many subjects I have seen it separated from the posterior wall of the canal by a very short distance, for instance, from an eighth to a quarter of an inch. It can be seen, therefore, that in operating upon the mastoid the region of safety lies within the small triangle already mentioned. The higher the operator goes above the superior wall of the meatus, the more is he in danger of encroaching upon the middle cranial fossa. The farther he goes behind the posterior margin of the bony meatus, the more danger there is of encroaching upon the lateral sinus.

Bearing these points in mind, the mastoid operation is performed as follows:

The field of operation is thoroughly sterilized by shaving the head for a distance of three inches from the center of the meatus in every direction. The parts are scrubbed in the ordinary way and a sterile dressing applied. It is not necessary to enter into details regarding the preparation. The

incision should begin about a quarter of an inch below the tip of the mastoid process, should pass upward over the tip of the process, and then follow the line of auricular attachment, the incision being located about a quarter of an inch behind this line. The incision should terminate at the superior attachment of the auricle. The incision should be carried through the integument and periosteum, down to the bone. Clamps should be applied to all bleeding points. By means of a periosteum elevator, the anterior flap, including the auricle, should be crowded forward, so as to expose the upper and posterior margins of the bony meatus. Posteriorly, the periosteum should also be elevated so as to expose completely the surface of the mastoid process. Retractors should then be inserted, widely separating the flaps. The next step is to clear the tip of the mastoid from the insertion of the sternomastoid muscle. This is best done by blunt scissors curved on the flat, the aponeurotic insertion of the muscle being divided close to the bone, until the finger can be passed completely beneath the tip of the mastoid. The next step should be to remove the entire mastoid cortex. This is best done by a large gouge. The bone is removed, preferably, in the long axis of the mastoid process, the gouge being carried from above downward, beginning at the level of the superior wall of the canal, and being carried down to the tip, the first groove being quite close to the posterior wall of the canal, and the cortex being removed by successive furrows of the chisel posterior to this, until its entire cellular structure is exposed. This procedure enables the operator to map out his future steps. The next point is to deepen the wound in the bone in the region of the triangle of election, that is, to enter the mastoid antrum. This is best done by means of gouges of varying size, always remembering that the larger the instrument which can be used, the greater the safety to the patient. In some cases, after removing the mastoid cortex, so much disintegration of the mastoid cells will be found that the free use of the curet will enable the operator to break down all the pneumatic structure of the mastoid and to easily enter the mastoid antrum. In cases operated on early, however, —and all cases should be operated upon early,—and also in certain cases in which the mastoid cells are poorly developed, the operator will have no guide to the mastoid antrum except the anatomic landmarks, namely, the small triangle already mentioned. It is therefore advisable to constantly bear in mind that the deepest part of the opening in the bone should always lie within this triangle, the opening in the bone being successively deepened by means of gouges and curets until the mastoid antrum is entered. The operator knows that the mastoid antrum has been entered from the fact that a probe introduced into the bony opening passes at first upward, and then downward, forward, and inward until it enters the free cavity of the tympanic vault. Having located the mastoid antrum, attention is next turned to the remaining mastoid cells. These are broken down by means of the curet, care being exercised not to penetrate the internal table or to plunge the instrument through necrotic dura into either the lateral sinus or the brain substance. As the cellular structure is broken down, the operator should gradually be able to map

out the course of the groove of the lateral sinus. This runs in a general direction, upward and backward from the tip of the mastoid, to a point about the level of the superior wall of the external auditory meatus, where it bends sharply backward, forming the knee of the sinus, the remaining portion of the sinus running horizontally backward to the torcular. Particular attention should be paid to those cells at the tip of the mastoid. In every acute case all tip cells must be removed. The tip of the mastoid is best removed with rongeur forceps, one blade of the forceps being inserted beneath the tip of the mastoid, while the other blade enters the cavity of the mastoid already excavated, the tip being cut off by closing the forceps. The tip cells should be removed until the digastric muscle is brought plainly into view. In other words, all those cells overlying the digastric should be taken away. In cases of extensive mastoid development it is necessary to obliterate the entire pneumatic structure of the mastoid. Cells will be found extending backward toward the occiput; in many cases they may also be found above the temporal ridge and may extend forward into the zygoma or into the squamous plate beneath the zygoma. It is imperative that all these pneumatic spaces be obliterated and that all overhanging edges be taken away by means of the rongeur forceps, so as to leave a comparatively flat surface of bone in every direction. It is particularly important to investigate the zygomatic cells, as frequently a focus of suppuration may be located in them and unless eradicated, it will cause a recurrence of the trouble.

In completing the work upon the bone it is advisable to remove a considerable portion of the posterior canal wall. This allows the anterior flap to sink backward into the mastoid cavity and greatly hastens the process of healing by favoring the early obliteration of the bony cavity.

Where the cellular structure is very well developed posteriorly, it is sometimes necessary to supplement the original curvilinear incision by an incision extending from the center of this, backward at right angles, for a distance of a half to three-quarters of an inch. This permits the elevation of two small flaps posteriorly and gives wider access to the mastoid cortex. In fully 90 per cent. of the cases operated upon, however, this second incision is absolutely unnecessary.

The appearance of the wound after complete obliteration of the pneumatic structure of the mastoid is well shown in Fig. 450.

After the cellular structure of the mastoid has been obliterated, two methods of dealing with the wound are open to the operator: The cavity may be packed with gauze throughout and treated as an open wound, which is the most conservative method of treatment, or the entire wound may be sutured and the cavity allowed to fill with blood, in the hope of obtaining healing by means of organization of the contained blood-clot.

Much has been written within the last few years in regard to this blood-clot method of healing.[2] The weight of evidence presented seems to show that most operators fail in their attempts to completely close the wound and secure complete organization of the blood-clot. This termination we should ordinarily expect, as it seems almost impossible that a septic cavity can be rendered so thoroughly aseptic by operation as to permit

of complete closure of the wound and the subsequent organization of a contained clot. I have tried this method in numerous cases, and in but one single instance has the result been satisfactory. I have, therefore, practically discarded this method. Between this method and the old procedure of packing the wound there is a middle stage which yields good results in a certain proportion of cases. Instead of introducing a tight packing into the mastoid cavity and permitting the wound to heal entirely by granulation, a strip of iodoform gauze may be introduced into the mastoid antrum, a few folds being allowed to fill the space left by the obliterated pneumatic cells, and the wound closed by interrupted sutures throughout one-half or three-quarters of its entire extent, depending upon the size of the bony cavity and the amount of pus found at the time of operation. When this method is employed, the dressing should be changed on the second day after operation, the stitches removed, and the gauze packing taken out. In very mild cases, after the removal of the packing, practically no secretion will be found in the cavity. Successive lighter and lighter daily packings of the wound, as the cavity contracts, will bring about a complete cure. This partial closure, with drainage, is applicable to a certain number of cases. The extent to which the wound should be sutured must depend upon the extent to which the mastoid was infected. Given very little infection, with a small mastoid, and the wound may be closed throughout a large portion of its extent. But given an extensive suppurative process within the mastoid, and the wound must be treated more as an open wound.

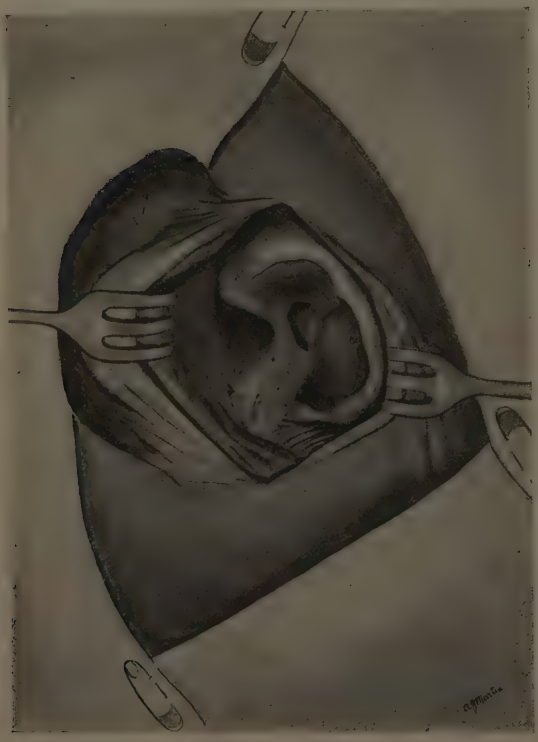

FIG. 450.—OPERATION FOR ACUTE MASTOIDITIS.

The entire pneumatic structure of the mastoid has been broken down. The tip of the mastoid has been removed, exposing the posterior belly of the digastric muscle. The sigmoid groove lodging the lateral sinus is well shown. The zygomatic cells have also been obliterated and a portion of the posterior wall of the bony meatus has been taken away. The deepest portion of the bony cavity leads directly to the aditus ad antrum. (Author's dissection.)

In cases in which the open method is followed, the first dressing may

be left undisturbed from two to four days, if the patient has no pain and the temperature remains normal. An elevation of temperature of more than a degree and a half always demands a change of dressing. After the primary dressing it is my usual practice to dress these cases daily or every second day. I have secured complete healing of a mastoid wound in ten days after operation. Such a result, however, is extremely rare, and the time before the wound has completely granulated has usually been from four to eight weeks. If the mastoid cells are very extensively developed, the period of convalescence may be longer.

Certain accidents may occur during the mastoid operation to which attention must be called. These are: first, injury of the lateral sinus; second, injury of the meninges; third, injury of the facial nerve. The lateral sinus is frequently exposed during the mastoid operation, but the exposure of this vessel is no menace to the life of the patient. If, however, the sinus is accidentally opened, there is some risk to life. First, on account of the possible aspiration of air into the right side of the heart through the opening in the sinus; second, severe hemorrhage—although this, in competent hands, need never constitute a serious difficulty; and, third, possible infection of the sinus, with the development of a septic clot, which may extend into the internal jugular vein. Because the sinus may be accidentally wounded by even the most skilful operator, the technic of operation previously described is recommended, namely, first, the early decortication of the entire mastoid, and, second, entrance of the mastoid antrum at an early stage of the operation. If these steps are carried out, the sinus will almost never be wounded early in the operation; in other words, most of the pus will have been evacuated from the mastoid prior to the accident, and the dangers of infection will be very much lessened. If the sinus is wounded, the operator simply places his finger over the opening and controls the hemorrhage. One extremity of a strip of iodoform gauze, about half an inch wide, is folded several times upon itself so as to make a small, firm compress or pad. This is grasped in the thumb forceps and is carried beneath the finger of the operator. Firm pressure with this pad of gauze will absolutely control the hemorrhage. It is surprising how small a compress is necessary to control even what seems to be a severe hemorrhage from the sinus. This bit of gauze is held in position with the thumb forceps, in the hands of an assistant, while the operator proceeds to complete the operation.

If the lateral sinus has been wounded care should be taken in the dressing of the mastoid wound, to pack off, first, the mastoid antrum and the cells by one gauze packing, to pack off the sinus area by a second gauze packing, and then to introduce what may be termed a "separation" packing between these two, so as to prevent possible infection of the sinus from the suppurating cells. Of course, if the sinus has been wounded, it will be impracticable to completely close the posterior wound by suture.

It is important to have the sinus wound in such a position that it can be easily seen at the first and subsequent dressings. In cases where the sinus has been wounded, the first dressing is not changed until the fourth or fifth day, unless a rise in temperature renders a change of dressing

imperative. At this time the careful removal of the pledget of gauze covering the sinus is scarcely ever followed by any hemorrhage, although I have seen the vessel bleed as late as the sixth or seventh day after operation. In no instance where this plan of treatment has been carefully followed out have I ever seen infection of the sinus follow an accidental wound of the vessel.

Perforation of the dura in the middle cranial fossa, or, occasionally, in the cerebellar fossa, is a rare accident. It may occur from the injudicious use of the gouge or curet. In one instance of this kind which came under my observation a small rent was made in the dura in removing a spicule of bone. This case made a prompt recovery, an isolation packing being employed over the region of the dural wound, in exactly the same manner as is used when the lateral sinus is opened. Careful technic will ordinarily prevent any serious result from either of these two accidents.

Injury of the facial nerve is exceedingly rare during a mastoid operation. I have seen this nerve injured once in over five hundred cases of which I have records. If it is remembered that the aqueductus Fallopii forms the floor of the aditus ad antrum, and if, in curetting the aditus, the curet is always turned either upward, forward, or backward, but never downward, the nerve cannot be injured.

A few words may be added in regard to the operation in very young children. In young infants it must be remembered that the mastoid antrum is the sole mastoid cell developed. Also that, owing to the absence of the bony canal, the mastoid antrum lies at a considerably lower level than the line of superior auricular attachment. It should be remembered, in operating upon young infants, that it is imperative to expose the tympanic ring, in every instance, before attempting to enter the mastoid cortex, and that the cortex should be entered just behind the posterior tympanic spine. Most operators, in operating upon infants, open the bone at too high a level, and in this way may enter the middle cranial fossa. It should also be borne in mind, in operating upon young infants, that ossification has not yet taken place along the sutural lines, and that if firm pressure is made with the knife, either in making the primary incision, or with the periosteum elevator in lifting the periosteum, the cranial cavity may be entered at one of the sutural lines. Too firm pressure must not, therefore, be made upon the knife, nor must the periosteum be elevated with undue violence.

Another point of practical importance is that in doing a secondary mastoid operation upon cases previously operated upon the incision should always lie behind the previous cicatrix, and should always be made upon firm, healthy bone. If this rule is not followed, and the lateral sinus or dura has been exposed in the previous operation, the operator may at the first incision wound either the sinus or the dura, and be greatly handicapped in the further conduct of his operation.

The Radical Operation for Chronic Middle-ear Suppuration.—This operation is applicable to all cases of chronic suppuration of the middle ear. It has for its object the conversion of the tympanic

cavity, mastoid cells, and the external auditory canal into one large cavity, easy access to which can be obtained through the external auditory meatus, which is enlarged by the operative procedure. In the course of repair this operative cavity is completely dermatized. This prevents recurrent attacks of suppuration, and also guards against all danger of intracranial infection.

In addition to its employment for the relief of chronic suppuration, this operation also is employed successfully for the relief of cases of acquired atresia of the external auditory canal, due to a previous suppurative process. It is in these cases of acquired atresia that operative interference may be followed by good results. The operation is performed as follows:

The preparation of the patient is the same as for the ordinary mastoid operation. The incision begins at a point over the tip of the mastoid process and extends upward and backward, following the curvilinear line of auricular attachment upward to the superior attachment of the auricle. This incision is located somewhat further behind the line of auricular attachment than in performing the ordinary mastoid operation. It is my practice to make this incision about half an inch behind the line of attachment of the auricle. The soft parts are divided with a single sweep of the knife down to the bone, and the anterior flap, composed of soft parts, periosteum, and auricle, is rapidly elevated, the bleeding points being caught with pressure forceps in the usual manner. If the incision is placed half an inch behind the line of auricular attachment, the posterior flap need only be slightly elevated. The anterior flap is retracted until the upper and posterior margins of the bony meatus are clearly exposed. Then with the narrow periosteum elevator the fibrocartilaginous canal is separated from the bony meatus along the superior, posterior, and inferior walls, the dissection being carried carefully inward, as close to the drum membrane as possible, care being exercised not to rupture the fibrocartilaginous tube until this dissection has been carried close to the drum membrane. Next, with a full-sized gouge the cortex of the mastoid is rapidly removed from the posterior wall of the meatus backward for a considerable distance. In other words, the meatus is gradually enlarged behind by the removal of successive laminæ of bone and, at the same time, the wound behind gradually deepened in the region of the meatus. The mastoid antrum is then entered with a smaller gouge, the point of entrance being the suprameatal triangle—the one described as the region of election in speaking of the mastoid operation. After the antrum has been entered the operator then proceeds to break down the remainder of the posterior wall of the external auditory canal, and also the outer wall of the tympanic vault, that is, the inner extremity of the superior wall of the external auditory meatus. This procedure is best performed either under direct illumination by means of the forehead headlight or under illumination with the head-mirror. The removal of the external wall of the tympanic vault, that is, the inner extremity of the superior wall of the bony canal, and the removal of the postero-superior wall of the meatus, is, perhaps, one of the most difficult

parts of the operation. If the posterior wall is removed at too low a level, there is danger of injuring the horizontal semicircular canal and the aqueductus Fallopii, lodging the facial nerve. If in the removal of the inner extremity of the meatus the gouge is directed upward and inward at too sharp an angle, there is danger of passing completely through the roof of the tympanum and of entering the middle cranial fossa. It is therefore better, in every case, to enter the mastoid antrum, as first described, and then to break down the outer wall of the tympanic vault with the gouge until the tympanic vault and antrum communicate freely. Next, all overhanging bony edges may be removed by means of the curet. The horizontal semicircular canal will then be seen forming the floor of the aditus ad antrum. It should be remembered that the facial nerve lies just below the curved prominence of the horizontal semicircular canal. The malleus and incus, or what remains of them, will next be seen in the tympanic vault. These should be removed either by means of the curet or by the forceps. The hemorrhage during the operation, while never severe, may be sufficiently profuse to obscure the deeper portion of the wound, and render the operation tedious. The operation is greatly facilitated if the cavity is packed from time to time with strips of gauze saturated in a 1:1000 adrenalin chlorid solution. Such a firm packing, left in position for a few moments, will completely exsanguinate the walls of the cavity, and will permit of a thorough and complete inspection of the entire field. The bony cavity should then be carefully explored by means of the probe and all softened areas should be removed by the curet. Having brought into view the prominence of the horizontal semicircular canal, the operator then proceeds to remove what remains of the posterior wall of the bony canal; as close to the floor of the external auditory meatus as possible, it being borne in mind that the facial nerve lies in the aqueductus Fallopii, just below the horizontal semicircular canal, and then passes backward, downward, and slightly outward to its exit at the stylomastoid foramen. It therefore hugs the posterior wall of the canal closely for the lower two-thirds of its vertical diameter, at its inner extremity. It is accordingly safe to remove the posterior wall of the canal to the level of the floor of the meatus for the outer two-thirds of its extent. From this level a spur should be left, gradually sloping upward to join the prominence of the horizontal semicircular canal. In removing the posterior wall of the meatus it should be remembered that this wall projects anteriorly for a varying distance in different subjects, covering what is known as the "posterior tympanic space." In a chronic suppurative otitis this space is very frequently the site either of granulation tissue or of a cholesteatomatous deposit. The posterior tympanic space should, therefore, be obliterated, either by the cautious use of the gouge or by means of the curet. As the facial nerve is separated from the posterior tympanic space only by a very thin layer of bone, great care must be exercised in using either the gouge or curet in this region. We are certain that this projecting portion of the posterior wall of the canal has been completely removed when a bent probe, passed into the tympanum and over the internal wall of the middle ear, can be drawn outward along the posterior wall of the meatus without

catching upon any obstruction. We are also cognizant of the fact that the posterior tympanic space has been obliterated by the free view which we obtain of the stapes, if this still remains, or of the oval window, in case the stapes has been destroyed. The lower portion of the tympanic cavity also demands attention. The floor of the middle ear lies at a slightly lower level than the floor of the external auditory meatus, and in order to cause a complete dermatization of the newly formed cavity, the hypotympanic space must be completely obliterated. This is accomplished by the cautious use of the curet at the inner extremity of the meatus, the floor of the canal being gradually cut away to the level of the floor of the tympanic cavity. Care is necessary in this manipulation, as the dome of the jugular bulb may be exceedingly high, and may encroach upon the floor of the hypotympanic space or even upon the floor of the canal. In one instance I wounded the dome of the bulb in obliterating the hypotympanic space. On the anterior wall of the tympanic cavity it is necessary to remember the orifice of the Eustachian tube. In order to obtain a successful result in the radical operation, the tympanic orifice of the tube must be thoroughly curetted, so that this orifice may be completely obliterated during the process of repair and all communication with the nasopharynx cut off. This is best done by curetting the mouth of the tube with a small curet, the cutting-edge of the instrument being directed anteriorly and superiorly. If the curet is directed either backward or downward, there is danger of wounding the internal carotid artery.

It is necessary, in order to obtain a successful result, that all infectious areas should be removed from the middle ear and mastoid. In some cases the suppurative process will be limited to the tympanic vault, the mastoid antrum, and those cells lying in immediate relation to the middle ear and antrum. In other cases, however, we find that all of the cells of the mastoid are involved. In these cases it is necessary, in addition to the exenteration of the tympano-mastoid cavity, already described, to obliterate the entire pneumatic structure of the mastoid as well, removing the cells at the tip and as far backward as the cellular structure extends, in order to thoroughly remove every trace of disease. In the majority of cases in which the radical operation is performed the disease is limited to the region of the mastoid antrum, and the tip cells are not involved. In quite a large proportion of cases, however, the entire mastoid is diseased, and complete ablation of the mastoid, with the obliteration of all its cellular structure, must be performed if a complete cure is to be hoped for. The operator should not hesitate, in performing the radical operation, to expose the lateral sinus, if the cells over this seem diseased, and the same may be said of the dura in the middle cranial fossa. In fact, many operators remove the roof of the tympanum and mastoid antrum in every case of chronic suppuration, as a routine procedure.

In a certain number of cases the suppurative process is not limited to the middle ear, but extends into the labyrinth. Sometimes the symptoms of labyrinthine involvement are sufficiently pronounced to enable the surgeon to make a proper diagnosis prior to the operation. As

already mentioned in the earlier pages, in considering chronic suppuration of the middle ear, vertigo may be a prominent symptom. In every case in which vertiginous symptoms are pronounced the surgeon should, at the time of operation, search most carefully for a perforation of the horizontal semicircular canal or for any evidences of suppuration of the labyrinth, as evidenced by a discharge of pus either from any one of the semicircular canals or from the oval window. Granulations about the oval window are exceedingly significant of possible labyrinthine suppuration. These should be carefully removed by means of the curet, and if the oval window is found open, and especially if pus can be seen to flow from it, it will be necessary to thoroughly drain the labyrinth, in order to secure a successful result. The same remark applies if a fistulous opening is found in the horizontal semicircular canal. The extent of the operative procedure upon the labyrinth depends upon the extent of involvement. If only a small area of one of the semicircular canals is found to be carious, it will be sufficient to curet away this carious area, open the lumen of the canal for a sufficient distance to secure free drainage, and to pack off this infected area with a strip of iodoform gauze. Naturally, with caries in this region, primary grafting of the cavity would be out of the question. If a semicircular canal contains considerable pus, or if pus is seen flowing from the oval window, it is wise to destroy the labyrinth with fair completeness, in order to secure free drainage. If there is involvement of a semicircular canal and the vestibule as well, the outer wall of the canal should be thoroughly curetted away, so as to freely open its lumen. Sufficient bone should be removed to admit of a probe being carried through the canal into the vestibule. It is then wise to enlarge the oval window in a direction downward and forward, so as to thoroughly drain the entire labyrinth. If the opening of the oval window is enlarged upward, the integrity of the facial nerve will be in danger, consequently any enlargement of the oval window must be in a direction downward and forward. In other words, the prominence which forms the outer wall of the first turn of the cochlea must be taken away. Sufficient bone must be removed in every instance to completely drain the infected area. If care is taken not to remove the inferior wall of the horizontal semicircular canal, while at the same time the oval window is not enlarged upward, complete drainage of the labyrinth may be secured without interfering with the facial nerve. In any case in which labyrinthine drainage is required, primary grafting cannot be employed in concluding the radical operation. It is necessary that all suppuration in this region should be thoroughly cured before the cavity can be covered with skin grafts.

The next step is the enlargement of the external auditory meatus by a plastic operation, so that all parts resulting from the operation may be thoroughly accessible through the external auditory meatus.

Several methods are in vogue for forming this flap. Some operators prefer to split the external auditory meatus by a median longitudinal incision, from its inner extremity well out to the middle of the concha, and then to make one incision upward and another downward through the entire thickness of the concha at right angles to this incision. On dis-

secting out the cartilage two flaps are formed—one which is stitched upward upon itself, and the other downward, thus increasing the caliber of the meatus. At the same time the reflected cutaneous edges will, on replacement of the auricle, and the apposition of the margins of the posterior incision, form a cutaneous lining for a portion of the radical cavity. This method is known as the "Panse method."

Another method is to make one incision along the supero-posterior aspect of the meatus, extending this incision well out into the concha, and a similar incision along the postero-inferior aspect. This gives a quadrilateral flap from which the cartilage may be dissected, and allows of the displacement of a tongue-shaped flap of integument inward, partially lining the bony cavity. This is "Körner's method." The flap which I have employed in all of my operations is a modification of the flap advocated by Mr. Charles A. Ballance, of London, and consists in splitting the fibro-cartilaginous meatus along its inferior aspect as far as the meatus. The knife is then carried upward and backward, cutting a tongue-shaped flap from the concha. The extent of the flap cut from the concha depends upon the size of the radical cavity formed, and also upon the degree of infection found in the individual case. If the radical cavity is very large, a very large flap must be cut from the concha. If the cavity is small, and the infection has not been severe, a smaller flap will do. The incision in the concha is carried upward as far as the anterior crus of the antihelix. All cartilage is dissected out from this flap, preferably by elevating the integument in the concha and dissecting the cartilage out with the auricle in its normal position. Exceptionally, this dissection is best made by retracting the tongue-shaped flap into the posterior opening and removing the cartilage through the opening. In all cases in which the suppurative process has been very extensive con-

FIG. 451.—THE RADICAL OPERATION FOR CHRONIC MIDDLE-EAR SUPPURATION.

The illustration shows the complete exenteration of the tympano-mastoid cavity. The horizontal semicircular canal and facial spur are well shown. Also the oval and round windows. The concha-meatal flap is also shown stitched in position (Author's dissection).

siderable thickening of the upper portion of the meatus will be found. This thickened fibrous tissue is removed as well as the cartilage. After the skin flap has been formed (see Fig. 451) it is reflected upward and backward, and its raw surface stitched to the corresponding raw surface of the anterior flap. In this way a tegumentary lining for the upper and posterior portion of the radical cavity is formed.

The cicatrization of the cavity left after the radical operation is greatly accelerated by lining the cavity completely by a large Thiersch graft at the time of the operation. This graft should be of sufficient size to cover entirely the tympanum, tympanic vault, mastoid antrum, and entire mastoid cavity exposed at the time of operation. It is much better to employ one large single graft than to attempt to apply several small grafts to the cavity. Mr. Ballance, in his admirable articles on this subject, has advocated grafting as a secondary procedure. This, I believe, is unnecessary in quite a large proportion of cases, as the graft can, in most instances, be introduced at the time of the operation, and in this way, the patient is spared the necessity of a second anesthesia.

If primary grafting is to be employed, the procedure will be greatly facilitated by packing the bony cavity with a strip of gauze moistened in a 1 : 1000 adrenalin chlorid solution, leaving the strip in position while the grafts are being cut. It has also been my practice, when oozing from the cutaneous flaps has been troublesome, to pack the cutaneous wound in the same manner. By the time the Thiersch grafts are ready—and these are taken from the thigh in the usual manner—the entire operative field will be found absolutely dry. In inserting the Thiersch grafts the method first suggested by Mr. Ballance is the ideal procedure. A large graft is placed upon the spatula (Fig. 452, E) or upon a glass slide, and this graft is slid over the entire cavity so as to bridge it, as it were. The graft is then slightly pressed inward at its center by means of the probe until it roughly fills the cavity. A glass pipet is then introduced beneath the edge of the graft, and by means of suction the air is exhausted from the cavity. The graft is immediately crowded inward by atmospheric pressure, so that the entire radical cavity is lined with the graft. In using the pipet the instrument is first introduced into the lower and anterior portion of the cavity, directly over the Eustachian tube. When the air is exhausted, the graft drops in over the facial ridge, lines the entire lower portion of the middle-ear cavity, and closes the opening in the Eustachian tube. The pipet is then cautiously withdrawn along either the floor or anterior wall of the cavity, and is inserted posteriorly above the facial ridge so as to exhaust the air beneath the graft in the region of the tympanic vault and antrum. The suction on the pipet is kept up as the instrument is withdrawn, in order to remove all air-bubbles. If the procedure is skilfully performed, the entire operative cavity will be seen to be covered completely by the thin Thiersch graft. In certain places an air-bubble will be found separating the graft from the wall of the bony cavity. This air-bubble should be removed by introducing the pipet cautiously a second or even a third time, exhausting the air. When the graft thoroughly lines the cavity, it is held in position by pledgets of cotton

impregnated with aristol or some similar powder. These pledgets are packed in lightly until the entire cavity is filled, and the graft is pressed gently against the walls of the cavity in every direction. The raw surface left by cutting the conchal flap is next grafted. This may be done before the posterior wound is sutured, by introducing a Thiersch graft into the posterior wound and wrapping it about the cut margin of the concha, so that one edge of the graft lies just within the posterior wound and the other edge projects from the orifice of the external auditory meatus, the graft being wrapped around the cut edge. This is undoubtedly the procedure of election.

In cases in which secondary grafting is to be performed, the technic of the operation is exactly the same, only the procedure is carried out

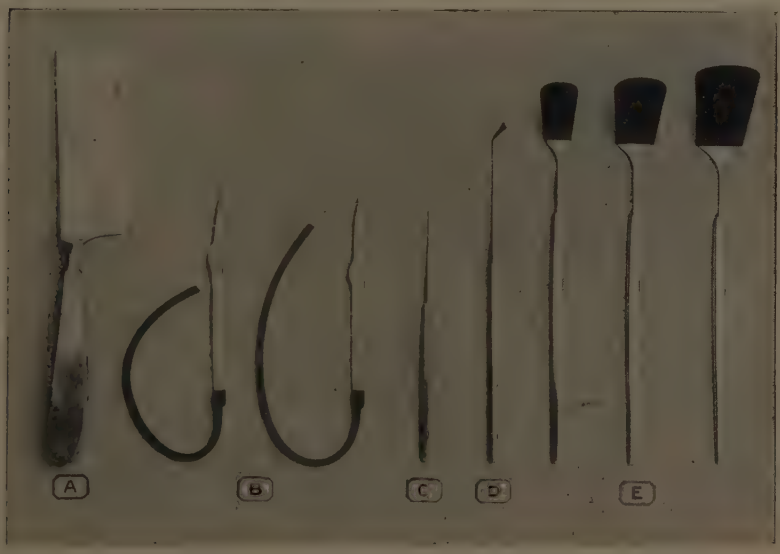

FIG. 452.—BALLANCE'S INSTRUMENTS FOR SKIN GRAFTING (Dench).

A, Large razor for cutting grafts; B, pipets for removal of air and blood from beneath the grafts when in position; C, needle for manipulating graft; D, blunt instrument for pressing graft on bony wall and for packing pledgets into tympanic cavity to hold grafts in position; E, broad spatulæ upon which graft is spread and from which it is carried into the tympanic cavity.

from three to ten days after the primary operation. Whether grafting is employed either primarily, or whether the operator decides to allow the cavity to heal by dermatization from without inward, the posterior wound is closed completely in every case of radical operation, except in those cases in which there has been a considerable exposure of the lateral sinus and where the disease in the region of the sinus has been so extensive as to render it unsafe to completely close the posterior opening. In these cases the posterior wound is closed throughout the greater portion of its extent, and a small strip of iodoform gauze is introduced over the sinus and brought out at the lower angle of the posterior wound. Personally, I never do a complete primary grafting of the tympanic cavity in cases in which there has been any considerable exposure either of the lateral sinus

or of the dura in the middle cranial fossa. I believe that grafting would be perfectly safe in the very large proportion of these cases. In a very small proportion of cases, however, such a procedure might be followed by infection of the intracranial structures, and, therefore, I do not employ it as a routine procedure when there has been an extensive exposure of sinus or dura. In cases in which there has been very extensive destruction of bone in the middle ear, and in which there seems to be some doubt as to the possibility of removing every vestige of the disease at the time of the primary operation, I am inclined to allow the case to heal either by dermatization from without,—that is, to simply pack the external auditory meatus with iodoform gauze, after suture of the posterior wound, and allow the case to proceed without further interference,—or I employ a secondary grafting about ten days after the primary operation. In employing a secondary graft, we have an opportunity of again inspecting the cavity under anesthesia, and if any trace of disease has been left, of eradicating this prior to the application of the graft. In applying the secondary graft it is only necessary to gently curet the fresh granulations which have formed in the middle ear during the period that has elapsed since the primary operation, check the hemorrhage by the use of either hydrogen peroxid or adrenalin chlorid, and then apply the graft in the manner already described. Although in every case the posterior wound is sutured at the time of the primary operation, this posterior incision is easily broken down, even ten days after the operation, by simple traction on the auricle and the use of a blunt dissector along the line of incision. After the secondary graft has been introduced the line of incision is again sutured, the dressing being exactly the same as that employed after the primary grafting. In cases of extensive exposure, either of the dura in the middle cranial fossa or over the lateral sinus, as before stated, primary grafting is not employed. In these cases the dural area is isolated by a strip of iodoform gauze packing and a second strip of iodoform gauze isolates the remainder of the operative cavity. Both of these strips are brought out at the external auditory meatus and the posterior wound is sutured. In these cases I have found it advisable to apply a graft through the external auditory meatus at the time of the primary operation after suture of the posterior wound. This graft is introduced so as to cover completely the margin of the concha, cut in the formation of the flap, and also that portion of the floor of the meatus incised during this procedure. This graft is easily slid into position and is held in place by a packing of sterile gauze. A similar meatal graft may be employed in cases in which primary grafting is used, instead of inserting the meatal graft posteriorly, if the operator prefers. It is of great importance to employ a meatal graft in every case, as in this way the formation of granulations about the margin of the enlarged meatus is avoided, and the patient is spared much pain during the process of healing.

Regarding the results of the radical operation, I can say that in a series of over two hundred and fifty cases complete cure has resulted in over 85 per cent.

Regarding the function of the organ, the hearing has been made worse in less than 2 per cent. of the cases. It has been much improved in quite a large proportion, and in the balance the hearing has remained the same as before the operation.

Intracranial Complications of Middle-ear Suppuration.—The intracranial complications of middle-ear suppuration comprise, first, general meningitis; second, localized meningitis or epidural abscess; third, sinus thrombosis; and, fourth, brain abscess. Under brain abscess we have to consider, first, cerebral abscess, and second, cerebellar abscess.

In this chapter, at the request of the editor, these intracranial complications can only be considered most briefly. A more complete consideration will be found in the chapter on the Surgery of the Head, Chapter XXXVI in Vol. III.

From an otologic standpoint, while any of these intracranial complications may follow acute otitis media, they are, with the possible exception of epidural abscess and sinus thrombosis, more frequently found as a complication of chronic middle-ear suppuration. A few words will not be out of place in this chapter relative to each of these conditions.

General **meningitis,** of otitic origin, may be of either the suppurative or serous variety. The symptoms common to each variety are intense headache, elevation of temperature, vomiting, and constipation. The occurrence of these symptoms in any case of either acute or chronic middle-ear suppuration should always be regarded with suspicion. The headache in meningitis is usually general, but if localized, it may be occipital. The elevation of temperature, in the suppurative cases, is usually considerable, the temperature ranging from 103° to 104°. The temperature is fairly constant, the daily remissions being generally not over one or two degrees. If the meningitis is of the serous variety, the temperature elevation is not as great as it is in the purulent variety of the disease. Vomiting is also a characteristic symptom. It has well been called by some English authors "purposeless" vomiting, that is, vomiting unattended with nausea, and persists in spite of internal medication. Constipation is a symptom which is considered important by certain authors, notably, Mr. Ballance, of London, but has not been a marked symptom in my own cases.

Associated with the above-mentioned symptoms we usually have photophobia, a rapid pulse in the early stages of the disease, followed by a slow pulse, as the disease progresses.

In otitic meningitis the base of the brain is most frequently involved, owing to the fact that infection takes place through either the roof of the middle ear or the roof of the mastoid, involving the dura at the base of the temporo-sphenoidal lobe, or infection may take place along the posterior surface of the petrous pyramid, over either the lateral sinus, the aquæductus vestibuli, or the internal auditory meatus.

Muscular symptoms, either convulsive or paralytic, may occur in the course of a meningitis, and are naturally referable to the base of the brain. Rigidity of the neck is quite common in otitic meningitis, especially in

children, and may be an early symptom. Contraction of the pupil on the affected side, followed by dilatation of the pupil, as the disease advances, is also met with. Of the ocular paralyses, paralysis of the sixth nerve is frequently observed, the patient having internal strabismus upon the affected side. Respiratory symptoms occur late in the disease and are an evidence of involvement of the fourth ventricle. When this region is involved, the respiration becomes Cheyne-Stokes in character. A physical sign of great significance, in cases of meningitis, is found in the fundus oculi upon ophthalmoscopic examination. In quite a large proportion of these cases we find, in the early stages, dilatation and tortuosity of the veins, and in the later stages true choked disc. This sign usually appears upon the side of infection, but may appear upon both sides. In both the serous and purulent variety of meningitis the ventricular cavities sooner or later participate in the inflammatory process, and fluid accumulates within the ventricles of the brain.

The *treatment* of this condition is essentially surgical. Valuable information can also be obtained in doubtful cases by lumbar puncture. Ordinarily, in either the serous or purulent variety, lumbar puncture will show increased pressure of the cerebrospinal fluid. In the serous variety the fluid withdrawn is usually clear; in the purulent variety the fluid may contain a large number of polymorphonuclear cells and may be turbid. It is usually turbid in the later stages of the disease. A bacteriologic investigation of the fluid will often reveal the pathogenic organism, although this is not invariably the case.

The successful treatment of otitic meningitis is entirely surgical. In the very early stages the suppurative focus within the middle ear should be eradicated and efforts should be made to prevent the extension of the inflammation. Unfortunately, very few cases are seen early enough to render this method available, and its employment is practically restricted to those cases of acute mastoiditis which, when they first present themselves, show some meningeal symptoms. In addition to removing the purulent focus within the mastoid, early lumbar puncture is undoubtedly of great advantage in relieving the intracranial pressure. It should be employed in all cases early, and if relief follows, should be repeated whenever the signs of increased intracranial pressure recur. In the more advanced cases an occasional favorable result will be obtained by following up the tract of infection from the middle ear to the meninges and freely incising the dura. In one case reported by the author[3] drainage of the subdural space over the tympanic roof was followed by recovery. If the avenue of infection can be traced from the middle ear to the cranial cavity, this tract should be followed up, the dura freely incised, and gauze drainage inserted, thus accomplishing the twofold purpose of draining the infected area, and also of walling off the infected meninges from the subarachnoid space. In the more advanced cases it may be wise to drain the subdural space directly, either over the tympanic roof or in the cerebellar fossa, doing a decompressive operation simply for the relief of intracranial pressure. At such an operation the ventricles may or may not be tapped, according to the symptoms, and according to the choice of the

operator. I have never had a successful case following draining the ventricles, although I have performed this operation several times. In conjunction with the decompressive operation, subdural drainage, and ventricular drainage, repeated lumbar puncture may also be employed, occasionally with success.

Epidural Abscess.—An epidural abscess is an effort on the part of nature to confine a meningeal infection to a localized area, and thus prevent general meningitis. An epidural collection of pus may lie either above the tympanic roof in the middle cranial fossa, on the posterior surface of the petrous pyramid in front of the lateral sinus, or it may lie over the sinus or even occasionally behind this vessel. Epidural abscess gives rise to so few symptoms as to render its recognition prior to operation practically impossible. These extradural collections of pus are most usually found during the course of an acute mastoid operation. The only symptoms which may occur are localized headache—the headache being usually confined to the site of the pus collection—and tenderness on percussion over this particular area. These symptoms may be present or may be absent. In addition to these symptoms, we usually have a moderate elevation of temperature, the temperature seldom rising, however, above 102°, and frequently not above 101°. As before stated, extradural purulent collections are met with accidentally at the time of the complete mastoid operation. They are to be suspected, however, in every case of mastoid involvement with acute symptoms, in which localized headache is present, rather to the exclusion of pain in the ear or pain in the mastoid, and if there is a temperature of 101° or 102° in adult cases. As stated in discussing mastoiditis, suppuration within the mastoid frequently gives rise to no elevation of temperature, and in adults the temperature is seldom over 100° or 101½°. The treatment of epidural abscess is extremely simple. It consists in the removal of the inner table of the skull, thoroughly evacuating the abscess. The inner table should be removed over the entire involved area, but not beyond this. The line of demarcation is indicated by firm adhesions between the dura and the bone, and these should not be broken up, but the bone should be removed to the very edge of the line of adhesion, so as to freely open the entire abscess cavity. Exposure of healthy dura beyond the line of adhesion is inadvisable. After evacuation of the pus, the abscess cavity is packed with gauze, and the wound is dressed in the usual way.

Sinus Thrombosis.—A septic thrombus in the lateral sinus is a not uncommon sequel of neglected middle-ear suppuration. It follows both acute and chronic middle-ear suppuration, and is, perhaps, equally common in both varieties. When occurring as a complication of chronic suppurative otitis, it usually follows an acute exacerbation of this condition.

The *symptoms* of sinus thrombosis are generally sufficiently characteristic to make its recognition possible. The most characteristic sign is a sudden and abrupt rise of the temperature to 104°, 105°, or 106°, followed in a few hours by a sudden fall in the temperature to 100°, or even to the normal standard. This remission or intermission in temperature lasts

but a few hours, when the temperature again rises quite abruptly to its previous elevation, only to fall again spontaneously to near the normal standard. Such abrupt temperature variations in any case of either acute or chronic middle-ear suppuration should be looked upon as strongly indicative of sinus thrombosis.

Infection of the sinus may take place either through the posterior antral wall, at a point between the knee of the sinus and the bulb, or, in rare cases, the infection may take place directly through the floor of the tympanic cavity, and the thrombus form first in the jugular bulb itself. A formation of a clot in this latter locality seems to be rather more common in infants than in adults. If infection takes place directly from the middle ear, the symptoms of sinus thrombosis may appear very early in the course of a middle-ear inflammation, and without any evidence of mastoid involvement. In fact, in a number of these cases in which a septic clot has been found in the jugular bulb, and has been successfully removed by operation, the mastoid cells at the time of operation were found to be absolutely free from disease.

While the wide excursions in temperature constitute the most characteristic sign of sinus thrombosis, certain other symptoms may be present. Severe rigors, preceding the temperature elevation, and profuse sweating, as the temperature falls, are observed in a certain number of cases. My own experience has been that rigors are the exception rather than the rule, although profuse perspiration accompanying a fall in temperature is not at all uncommon. One of the chief characteristics of the condition is the absence of other general symptoms. These patients complain of no discomfort, aside from that attendant upon the elevated temperature; their mental condition is invariably clear, except when the temperature is at its highest point, when they may appear slightly dull, and, in rare cases, slightly delirious. The pulse is usually rapid and there is little or no headache. The blood count in these cases will usually show an increase in the percentage of polymorphonuclear cells, although this is not an invariable rule. Paralytic symptoms do not occur. Choked disc, either in the eye corresponding to the affected side, or upon both sides, has been observed. The treatment of the condition consists in the thorough removal of the clot from the lateral sinus. This suffices, in cases seen early, to effect a complete cure. In cases in which the bulb is involved it is necessary to excise the internal jugular from a point low down in the neck to a point close to the base of the skull, in addition to the removal of the clot from the sinus, in order to prevent further systemic infection. In some cases it is necessary to lay bare the entire jugular bulb in addition to excising the internal jugular vein. This operation was first elaborated by Grunert.[4] In connection with the excision of the internal jugular, it should be said that in case the clot extends well down into the jugular, the vein must be excised from a point below that to which the clot extends. Grunert[5] has reported a case in which a ligature was placed around the jugular just above the innominate vein. I have also ligated the vein at this point.

Brain Abscess.—Abscess of the brain substance complicating puru-

lent otitis media may occur either in the cerebrum or cerebellum. According to my own statistics of cases operated upon, the cases of cerebral abscess outnumber those of cerebellar abscess in the proportion of three to one. Mr. Ballance,[6] of London, states that cerebellar abscess is more frequent than cerebral abscess when the brain suppuration is secondary to otitis media. It should be stated that Mr. Ballance's statistics are based upon a large number of autopsies, while my own statistics are based upon cases operated upon. The discrepancy between these two reports shows how frequently an abscess of the cerebellum may be present without any clinical manifestations whatever, and may be discovered only after death.

The *symptoms* of brain abscess may be divided into two classes: first, those indicative of a suppurative lesion, and, second, localizing symptoms, according to the location of the abscess. The symptoms depend upon the presence of pus in the brain, irrespective of its location, and may be so slight as to be completely overlooked. This stage constitutes the initial stage of cerebral abscess. The characteristics are a moderate elevation in temperature of 101° or 102°, or sometimes less than this, together with headache and a feeling of general malaise or prostration. In cases of otitic origin these may be the only symptoms of abscess within the brain substance in the early stages. As the condition advances the patient usually becomes dull and drowsy. The above symptoms may occur in the early stage of a brain abscess, no matter where the brain abscess is located. The pulse in these cases often offers a valuable diagnostic sign in that, in spite of moderate temperature elevation, the frequency of the pulse-rate is usually reduced. One of the most valuable indications of a brain abscess is obtained by a differential blood-count. The percentage of polymorphonuclear cells is generally above the normal standard. In one of the cases which came under my observation this constituted practically the only differential sign between brain abscess and embolism of one of the cerebral arteries.

Another important diagnostic sign is the presence of choked disc. While this sign may be present in all of the intracranial complications of middle-ear suppuration, and simply indicates increased intracranial pressure, its presence in any obscure case, in which the characteristic symptoms of meningitis and sinus thrombosis are wanting, would be a fairly certain indication of a purulent focus within the brain substance.

Out of one hundred and two cases of cerebellar abscess of which I have records,[7] optic neuritis was present in thirty-four, it was absent in thirty-seven, and its presence or absence was not stated in thirty-one. Of one hundred and one cases of cerebral abscess, optic neuritis was present in thirty-two cases, absent in twenty-one cases, and in the remainder the condition of the fundus oculi is not stated.

The above symptoms are, in a general way, characteristic of the early stage of brain abscess. Some cases progress rapidly after the initial stage to a fatal termination or present symptoms sufficiently pronounced to render the diagnosis easy. In other cases, however, we have a subsidence of all the general symptoms. The fever and headache disappear, the

patient's mental condition becomes more nearly normal, and it would seem that he was improving. This stage may be called the "latent" stage of a brain abscess. There is one symptom, however, which is rather characteristic of suppuration within the brain even during this latent stage, and that is, in spite of the apparently improved condition of the patient, progressive emaciation occurs. This, I think, is one of the most important symptoms of a chronic brain abscess—the gradual loss of flesh, together with a gradual loss of strength. This latent stage of brain abscess is followed later by a third stage, which ordinarily proves rapidly fatal. The temperature rises suddenly, the patient becomes either delirious or comatose, the pulse at first becomes slow, but afterward becomes exceedingly rapid, and the patient dies in coma.

The above constitute, briefly, the general symptoms manifested in cerebral suppuration. When we come to the localizing symptoms, these will depend upon the situation of the abscess. In brain abscess of otitic origin, located in the temporo-sphenoidal lobe, localizing symptoms may be entirely wanting, provided the abscess is situated upon the right side. The right temporo-sphenoidal lobe may, as Mr. Ballance has stated, be called the "silent" lobe of the brain, as extensive purulent collections in this region may give rise to absolutely no symptoms. When the abscess is located in the left temporo-sphenoidal lobe, however, we usually have characteristic localizing symptoms. In other words, the patient generally suffers from some form of aphasia, either word-blindness or word-deafness. This aphasia may be either auditory or motor. The patient may either not be able to understand words spoken to him, or he may not be able to name objects or to write the names of objects. The latter two conditions are known as *aphemia* and *agraphia*. All of these symptoms point to a lesion of the superior convolution of the temporal lobe. True motor aphasia is situated usually in the posterior extremity of the inferior frontal convolution or in the island of Reil. Abnormalities in the sense of taste and smell are frequently spoken of as characteristic of lesions of the left temporo-sphenoidal lobe at its anterior extremity. These symptoms have not been present in the cases which I have seen. The presence of motor paralysis in a temporo-sphenoidal abscess of otitic origin, aside from the disturbances of the speech center, already referred to, are rare, if we exclude the ocular paralyses. Paralysis of the abducens nerve, on the side corresponding to the lesion, may occur in a temporo-sphenoidal abscess, as has been observed by the author. Other ocular symptoms are rare. If the abscess is situated in the occipital lobe,—and disease of otitic origin may be located here,—homonymous hemianopsia may occur. This would locate the abscess in the visual area, in the occipital lobe.

The localizing symptoms of an abscess of the cerebellum are exceedingly vague. As before stated, many of these abscesses are found only on post-mortem examination, having given rise to no characteristic symptoms during life. With a left-sided middle-ear suppuration, general evidences of a collection of pus within the brain, and no localizing symptoms, the inference would be that the suppuration lay below the tentorium. The characteristic localizing symptoms of a cerebellar abscess are head-

ache, vomiting, and sometimes incoördination of both the upper and lower extremities on the affected side. The sensorium is usually dull, due undoubtedly to increased intracranial pressure. Out of one hundred cases carefully analyzed by myself, these were the most prominent symptoms. Not infrequently nystagmus is present. The pupils are usually unequal, the pupil on the affected side being contracted in the early stages of the disease, but dilated later. The temperature in these cases is frequently subnormal, although in the acute stage the temperature is elevated. The pulse is generally slow. The staggering gait of these patients is also characteristic. This depends upon the incoördination of the muscles of locomotion. They usually tend to fall to the side of the lesion, although they may fall to the opposite side.

The surgical treatment in these cases depends for its success upon the recognition of the avenue of infection. If during a mastoid or radical operation an area of carious bone leads us directly to a necrotic or discolored dural area, then, in the presence of cerebral symptoms, an incision through this infected area with the knife, and the evacuation of the brain abscess, will, in many cases, be followed by a cure. This applies equally to abscesses located in the middle cranial fossa, and to those situated below the tentorium. In the presence of cerebral symptoms, in a case of middle-ear suppuration, the surgeon should always examine with the utmost care those regions through which infection usually takes place, namely, the roof of the tympanum and mastoid antrum, in order to discover evidences of infection in the middle cranial fossa, and the posterior wall of the mastoid overlying the lateral sinus, in order to discover evidences of infection below the tentorium. Infection below the tentorium may also frequently occur from labyrinth suppuration, in which case it usually travels either along the internal auditory meatus or along the aquæductus vestibuli, causing infection of the cerebellum on the posterior surface of the petrous pyramid. In exploring, therefore, for abscesses of the cerebellum, the anterior surface of the cerebellar lobe should be first exposed by the removal of bone in front of the lateral sinus, extending this opening downward and inward as far as the internal auditory meatus, if necessary. If the path of infection is found, as evidenced by necrotic or discolored dura, incision in this area by means of a long, narrow knife may evacuate the purulent collection. Unfortunately, in many cases of intracranial suppuration, due to purulent otitis, the most careful examination fails to reveal the avenue of infection, and the operator must explore the brain substance, either above or below the tentorium, according to the symptoms present, in the hope of finding the abscess. In such exploratory operations, when apparently the disease is located in the middle cranial fossa, the most convenient region for exploration is the region just above the zygoma. A large flap, with its convexity upward, is turned down, and that portion of the temporo-sphenoidal lobe lying immediately above the external auditory meatus is exposed. This opening above the squama may be made to communicate with the mastoid operative cavity previously formed by the removal of the intervening bone, if this seems wise. It has been my custom, in these cases, to explore immediately the

temporo-sphenoidal lobe after the reflection of a dural flap, and in four out of ten cases of temporo-sphenoidal abscess treated in this way recovery followed. I am inclined to believe, however, that I shall follow the suggestion made by Mr. Ballance (*loc. cit.*) in regard to first incising the dura, and then packing the exposed area of the brain with iodoform gauze, and temporarily replacing the flap for from twelve to twenty-four hours. In this way the pressure within the brain is relieved, while at the same time the subdural space will be completely shut off by adhesions. The brain substance can then be incised after this interval, and upon the evacuation of the abscess, this cavity may be drained either by means of gauze drainage, the cigarette drain, or by means of tubes without much danger of infection of the meninges. Meningitis has been the cause of death in most of the fatal cases of cerebral abscess evacuated. If the direct path of infection can be found, and the abscess be opened along this path, such a danger does not exist, and this certainly constitutes the ideal method of dealing with these abscesses in either the cerebrum or cerebellum.

In cases of exploratory operations upon the cerebellum, the anterior surface of the cerebellum should be exposed in the manner already mentioned in speaking of cerebellar abscess. If the avenue of infection is not found, it is then wise to explore a large area of cerebellum behind the sinus by displacing a large semicircular flap downward and removing the overlying bone from the lateral sinus anteriorly to the median line posteriorly. A dural flap should then be turned down, the subdural space packed off, and a subsequent exploratory incision of the cerebellum performed in from twelve to twenty-four hours after the primary operation. I believe that exploratory operations carried out in this way will probably be more successful than if the brain substance is incised at the time of the primary operation.

Out of one hundred and two cases of cerebellar abscess of which I have records,[7] it is interesting to note that thirty-three cases were cured by operation. Forty-five cases were opened behind the lateral sinus. Of these, twenty-five were cured and twenty died. Eleven cases were opened in front of the lateral sinus; and of these, four were cured and seven died. In forty-six cases the method of operation is not stated. Of this number, there were four cures and forty-two deaths.

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CHAPTER LXV.

SURGERY OF THE EYE.

By G. E. de Schweinitz, M.D.,

PHILADELPHIA.

ANATOMIC CONSIDERATIONS.

The Orbit.—Each orbit consists of a somewhat cone-shaped cavity (cavity of the orbit) within a bony framework (walls of the orbit). Into this framework the frontal, sphenoid, ethmoid, superior maxillary, malar, lachrymal, and palate bones enter. If the frontal sinus is large, it lies just above the anterior half of the roof of the orbit, which is formed by the orbital plate of the frontal; hence a tumor or empyema of this region may readily encroach upon the orbit and cause displacement of the eyeball, double vision, etc.

The bony partition between the orbit and the cranial cavity is very thin and is readily penetrated by a foreign body, with resulting brain injury. The inner wall of the orbit, joined to the roof nearly at a right angle, passes in a moderate curve into the floor, and is made up of the orbital plate of the ethmoid, the nasal process of the superior maxillary, the lachrymal bone, and the body of the sphenoid. Behind the os planum of the ethmoid bone are the ethmoid cells, and more posteriorly the sphenoid cell or sinus. Tumors, empyema, or mucocele of these cells easily intrude into the orbital cavity through the thin partition, and infecting material from these cells may find its way through the anterior and posterior ethmoidal foramina, which are between the ethmoid and frontal. The superior maxilla, the malar bone, and the orbital plate of the palate bone form the floor of the orbit, beneath the larger portion of which lies the antrum of Highmore, from which the orbit may be encroached upon by tumors and abscesses. The malar bone, the external angular process of the frontal bone, and the great wing of the sphenoid form the outer wall of the orbit. The sphenomaxillary fissure bounds the floor of the orbit externally in the posterior two-thirds of its extent and opens into the zygomatic fossa. Between the greater and lesser wings of the sphenoid, running upward and outward, is the sphenoidal fissure, and near the lower end of this fissure is the apex of the orbit. This fissure opens into the middle fossa of the skull and transmits the third, fourth, ophthalmic division of the fifth and the sixth nerves, filaments from the cavernous plexus from the sympathetic, the orbital branch of the middle meningeal, a recurrent branch from the lachrymal artery, and the ophthalmic vein. This vein develops from the union of the superior ophthalmic vein, formed at the inner angle of the orbit by the fusion of

vessels coming from the supraorbital and angular vein, and the inferior ophthalmic vein, originating from a plexus of small veins in the floor of the orbit which communicate with the facial vein, and empties into the cavernous sinus. Its relation, or, rather, the relation of the superior ophthalmic vein, to the symptomatology of pulsating exophthalmos is most important. Just above and internal to the inner end of the sphenoidal fissure is the optic foramen, or the orifice of a canal which passes through the lesser wing of the sphenoid. Through this canal the optic nerve and ophthalmic artery enter the orbit.

The junction of the upper and the outer wall, at the front of which is the suture connecting the frontal with the malar and with the orbital plate of the greater wing of the sphenoid, while posteriorly is the sphenoidal fissure before referred to, constitutes the superior external angle of the orbit and is to be remembered in relation to Krönlein's operation (p. 907).

The junction of the upper and inner wall, at which is the suture connecting the frontal bone with the lachrymal bone in front and the orbital bone behind, and which contains the anterior and posterior ethmoidal foramina, constitutes the superior internal angle.

The junction of the outer wall and the floor, where may be seen the sphenomaxillary fissure, constitutes the inferior external angle.

Union of the lachrymal and orbital plate of the ethmoid with the superior maxillary and palate bones forms the inferior internal angle.

The orbital margins are formed above by the frontal bone, below by the malar bone and superior maxilla, externally by the malar bone, and internally by the nasal process of the superior maxilla. This base of the orbit is open in the skeleton, but in life is closed by the lids and the membrane which attaches their tarsal plates to the walls of the orbits.

Periosteum lines the walls of the orbit, firmly attached at the borders, but loosely to the bony walls. At the optic foramen it is continuous with the dura and with the outer sheath of the optic nerve. The sphenoidal and sphenomaxillary fissures are closed by this membrane, and at the sphenomaxillary fissure there is a development of involuntary muscular fibers. The loose connection of the periosteum to the orbital walls renders it possible to extirpate cleanly any morbid growth that may be contained within it (page 909).

Contents of the Cavity of the Orbit.—The orbital cavity is occupied by the eyeball and its attached membranes, the lachrymal gland, the orbital fat and the orbital muscles, together with the nerves, blood-vessels, and lymphatics associated with these structures. Behind the eyeball and its membranes, which occupy the anterior wider half of the orbital cavity, as well as in the spaces between the muscles, vessels, and nerves, is the orbital fat, a structure which may be the seat of inflammation, abscess, tumors, foreign bodies, and emphysema. This orbital fat is separated into lobules by partitions or septa from the orbital fascia, which is analogous to the deep fascia of other locations, and which forms the sheaths for the muscles, vessels, and nerves of the orbit. The anterior layer of this orbital fascia blends with the periosteum at the orbital margin and

the palpebral fascia of the eyelids. Beneath the eyeball it is so strongly developed that it has been called the *suspensory ligament of the eyeball* and prevents the sagging of this organ after excision of the superior maxilla. This anterior lamina is also especially developed where the four recti muscles are situated, and there forms the *check ligaments*, of which the external and internal are the stronger. These ligaments probably prevent excessive retraction of the belly of the recti muscles after their tendons have been divided.

The posterior two-thirds of the eyeball is inclosed in *Tenon's capsule*. This membrane, lying beneath the muscle fascia, near the cornea fuses with the conjunctiva into a single membrane. Afterward these two separate, and the thin transparent tissue of which the capsule is formed follows the curve of the sclerotic from the insertion of the recti muscles close to the optic nerve entrance, where it leaves the eyeball and can be traced backward over the optic nerve-sheath. The space between it and the nerve-sheath is called the *supravaginal lymph-space*, and the one between the capsule and the eyeball is known as *Tenon's space;* they communicate with each other and are lymph-spaces. The ocular muscles pierce, or, to use the language of Dwight, invaginate Tenon's capsule, which invests their tendons at the points where their own sheaths cease. Therefore in tenotomy of the ocular muscles this capsule must be opened before the tendon can be exposed, and after the eyeball is enucleated this membrane is the most interior structure which is visible and which everywhere bounds the surrounding orbital fat. It is into this cavity that an artificial eyeball of glass, paraffin, or gold, is placed in the operation of implantation (page 904). The statement, often made, that the posterior two-thirds of the eyeball and the capsule of Tenon form a ball-and-socket joint, facilitating the rotary and gliding movements of the eyeball, as Dwight points out, is inaccurate, because Tenon's capsule is so closely attached to the globe near the cornea that it is impossible that one should move while the other remains still. Both move, without doubt, in the cushion of fat behind them.

The muscles of the orbit are seven in number, six of which are inserted into the eyeball, and are therefore commonly called the *exterior* ocular muscles. The seventh, or elevator of the upper lid, is inserted into the structure from which it takes its name. For the proper performance of tenotomy or advancement of the ocular muscles (page 896) their origin, insertion, and chief actions must be understood.

1. The *external rectus* arises by two heads, respectively from the outer margin of the optic foramen and the common tendon of the inferior and internal recti, and in part from a process of bone on the lower margin of the sphenoid fissure. Its tendon is inserted into the sclera 7 mm. from the margin of the cornea. It is supplied by the sixth or abducens nerve. Its pre-eminent action is abduction—that is, it rotates the eye directly outward.

2. The internal rectus arises from the optic foramen by a tendon common to it and the inferior rectus, and passes forward to be inserted by a tendinous expansion into the sclerotic coat 5 mm. from the margin of the cornea. It is supplied by one of the three branches of the inferior division of the third or oculomotor nerve. Its pre-eminent action is adduction—that is, it rotates the eye directly inward.

3. The superior rectus arises from the upper margin of the optic foramen and from the fibrous sheath of the optic nerve, and is inserted by a tendinous expansion

into the sclerotic coat 8 mm. from the margin of the cornea. It is supplied by the superior division of the third or oculomotor nerve. Its pre-eminent action is elevation or superduction—that is, it rotates the eye upward. It also adducts it and rotates the upper end of the vertical meridian of the cornea inward.

4. The inferior rectus arises from the optic foramen by a tendon common to it and the internal rectus and passes forward to be inserted by a tendinous expansion into the sclerotic coat 6 mm. from the margin of the cornea. It is supplied by one of the three branches of the inferior division of the third or oculomotor nerve. Its pre-eminent action is depression, or subduction—that is, it rotates the eye downward. It also adducts and rotates the vertical meridian of the cornea outward.

5. The superior oblique (trochlear) is situated at the upper and inner side of the orbit, and arises above the inner margin of the optic foramen. It proceeds to the inner angle of the orbit, at which point its rounded tendon passes through a fibrocartilaginous pulley occupying a fossa just within the supraorbital margin of the frontal bone, and is then reflected backward, outward, and downward, to be inserted about 18 mm. from the edge of the cornea between the superior and external recti. It is supplied by the fourth or trochlear nerve. Its pre-eminent action is intorsion—that is, it rotates the vertical meridian inward. It also depresses the eye and abducts it.

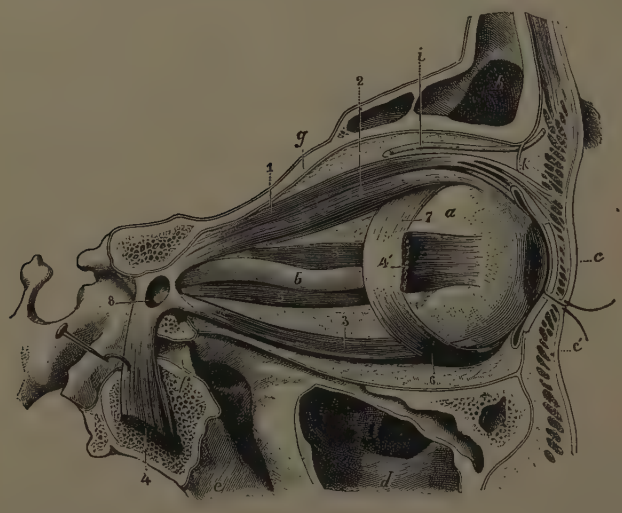


FIG. 453.—OCULAR MUSCLES VIEWED AFTER REMOVAL OF LATERAL WALL OF ORBIT (Testut).

a, Eyeball; *b*, optic nerve; *c*, *c'*, eyelids; *d*, maxillary sinus; *e*, pterygoid plate; *f*, foramen rotundum; *g*, roof of orbit; *h*, frontal sinus; *i*, supraorbital nerve; *k*, septum orbitale; 1, levator palpebræ superioris; 2, 3, superior and inferior recti; 4, 4', portions of the cut external rectus; 5, internal rectus; 6, inferior oblique; 7, insertion of superior oblique; 8, annular ligament or tendon of Zinn.

6. The inferior oblique is situated at the bottom of the orbit and arises from a depression in the orbital plate of the superior maxillary bone. Passing beneath the inferior rectus, it is directed outward, backward, and upward, and reaches its insertion into the sclera by means of a thin tendon about 19 mm. from the corneal margin, within the position of the external rectus. It is supplied by the largest branch of the superior division of the third or oculomotor nerve. Its pre-eminent action is extorsion—that is, it rotates the vertical meridian outward. It also elevates the eye and abducts it.

The levator palpebræ superioris arises from the under surface of the lesser wing of the sphenoid bone above the optic foramen. The muscle passes above the superior rectus and terminates in a broad, thin tendon or aponeurosis, which is inserted into the upper border of the superior tarsus. It is supplied by the third or oculomotor nerve (Fig. 453).

The *lachrymal gland* lies in a depression in the orbital plate of the frontal bone near the front of the outer part of the roof (see also page 860).

The Eyeball.—The eyeball is a spheroid body which occupies the anterior part of the orbit. Its anterior posterior diameter is approximately 25 mm., and this measurement is to be remembered in connection

with the localization by means of the *x*-rays of foreign bodies contained within its coats. The globe is so situated that a line drawn from the upper to the lower orbital margin just touches the cornea, an important fact in estimating the degree of protrusion of the eyeball (proptosis, exophthalmos) which may occur under various pathologic conditions, as well as the degree of sinking in of the eyeball (enophthalmos). The back part of the eyeball is between 16 and 18 mm. from the optic foramen, and the entire globe occupies about one-fifth of the orbital cavity. When *in situ* it can best be explored from the outer side, the patient being required to look well inward as well as downward and inward and upward and inward. Under such circumstances the exploring finger can reach to the equator of the eyeball and even a little posterior to it. The eyeball can also be explored above and below and to the inner side, but the exploration is less satisfactory and the degree of sclera which can be exposed less elaborate.

The eyeball consists of three concentric coats, or tunics, which inclose its transparent contents. These tunics are:

(*a*) The *external fibrous tunic*, composed of the sclerotic and of the cornea.

(*b*) The *middle vascular tunic*, often known as the *uveal tract*, which includes the choroid, the ciliary body, and the iris, and to which the most important vascular supply of the eye is distributed.

(*c*) The *inner nervous tunic*, or retina, which is the terminal expansion of the optic nerve, and which contains the specialized neuro-epithelium, or percipient elements, which receive the impressions which are there transformed into those stimuli which, passing through the optic nerve and continuation of the visual pathway in the brain, ultimately reach the visual center in the occipital lobe.

External Tunic.—The maintenance of the form of the eyeball depends upon the outer or fibrous tunic, and the normal tension of the eye is represented by a column of mercury 25 mm. in height. Of the two portions of the fibrous external investment, the sclera forms five-sixths of it and is a complete investment except where pierced by vessels and nerves. The sclera is thickest near the optic nerve, which pierces it posteriorly, and is there about 1 mm. in thickness. It is thinnest at a point about 7 mm. from the corneal limbus, or beneath the expansion of the ocular tendons, but gains slightly in thickness at their insertions, being, however, only 0.35 mm. in thickness at the former and 0.6 mm. at the latter (Piersol). There is good anatomic reason, therefore, for the fact that scleral ruptures as the result of blows from blunt instruments are usually found 3 mm. from and concentric with the corneal margin, or, in other words, in the region where the sclera is naturally thinner than it is far posteriorly (see page 886).

Anterior to the equator are the tendinous insertions of the four recti muscles at distances from the corneal border which have already been noted (Fig. 454). In some persons' eyes the exact positions of these insertions can be seen through the overlying conjunctiva, episclera, and investing capsule. The two oblique muscles are inserted behind the

equator at more than double the average distance of the recti insertions (see page 852).

Directly beneath the sclera lies that portion of the uveal tract composed of the ciliary body and choroid, and the pigment of the latter structure is visible through thin scleras, especially in children, giving them a distinctly bluish tinge. The yellow sclerotic of the aged is due to the accumulation of adipose tissue. The framework of the sclera is composed of interlacing bundles of white fibrous tissue, in which exists a system of communicating lymph-spaces containing connective-tissue cells, the so-called *sclerotic corpuscles*.

In advance of the insertions of the tendons of the ocular muscles is the union of the cornea and the sclera, and the junction of these two unequally curved surfaces gives rise to the formation of a slight groove, known as the *scleral sulcus*. When the intraocular tension is greatly increased and the convexity of the cornea lessened, this sulcus may be obliterated.

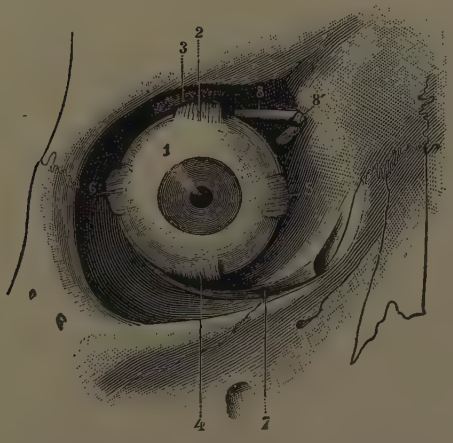


FIG. 454.—THE EYEBALL *in situ* WITH ITS MUSCLES AFTER REMOVAL OF SURROUNDING PARTS OF ORBITAL CONTENTS (Testut).

1, Eyeball; 2, superior rectus; 3, levator palpebræ; 4, inferior rectus; 5, internal rectus; 6, external rectus; 7, inferior oblique; 8, superior oblique; 8′, pulley and reflected tendon of same.

A zone of sclera 6 mm. in width directly surrounding the corneal margin is often spoken of as the *danger zone of the eye*, because just beneath it lies the ciliary body, and wounds in this region are of especial danger on account of their interference with the function of this important structure, as well as on account of the frequency with which, when improperly treated, or when they have become infected, they give rise to inflammation of the ciliary region of the opposite eye in the form of so-called sympathetic ophthalmitis.

At the anterior end of the sclera in its deeper layers, and passing circularly around the cornea, is the *scleral sinus*, or *canal of Schlemm*, which is a venous channel, and just in front of which, at the corneal limbus, the sclerotic merges, first through its deeper and finally through its superficial layers, into the other portion of the external fibrous tunic, which is known as the cornea. The important relation of the canal of Schlemm to the filtration of the internal ocular fluids through the anterior chamber, which will presently be described, must be kept clearly in mind, as must also the anatomy of the structures, superficial and deep, at this juncture, ordinarily known as the *corneoscleral junction* (Fig. 455).

The *cornea* constitutes the anterior one-sixth of the external fibrous tunic, is thickest at its periphery, where its diameter is 1.1 mm., and

thinnest at its center, 0.8 mm. It is composed of five layers: An external epithelial layer derived from the conjunctiva, beneath which is a homogeneous layer known as the anterior elastic membrane. Following this is the true substance of the cornea, succeeded by a posterior limiting membrane upon which rests the posterior endothelium. The corneal substance proper is composed of lamellæ of fibrous tissue, in many places separated by intervening clefts which constitute the so-called *corneal spaces*, and from these pass minute ramifications, the *corneal canals*, that communicate with adjacent spaces. These intercommunicating channels represent the lymph system of the cornea. Within the corneal spaces are the connective-tissue bodies known as the *corneal corpuscles*. The cornea, therefore, is permeated thoroughly with lymph, but contains no blood-vessels except the rich plexus which invades for about 1 mm. its periphery. The membrane is beautifully transparent, and constitutes one of the two chief refractive structures of the eye. It is richly supplied with nerves derived from the trigeminus.

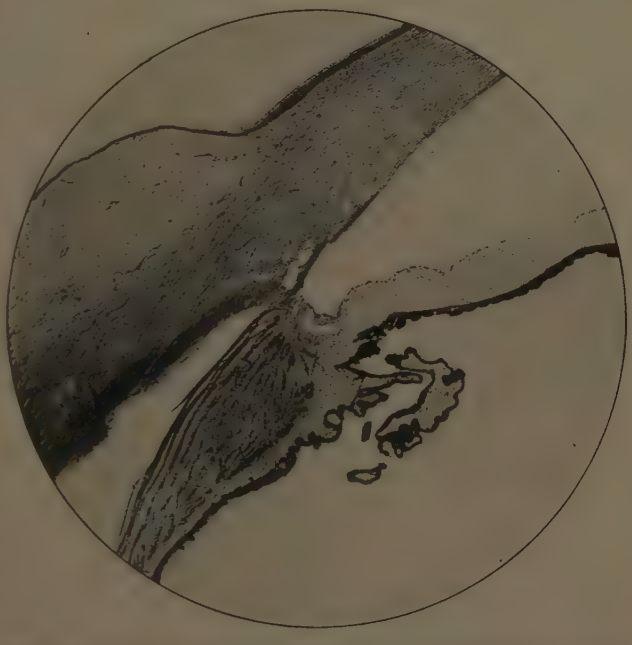


FIG. 455.—PHOTOMICROGRAPH SHOWING THE CORNEOSCLERAL JUNCTION (HUMAN). × 30.

The posterior elastic lamina, often called the membrane of Descemet, which both in anatomic arrangement and chemical properties differs from the corneal tissue itself, at its periphery develops a number of fibers which pass over to the base of the iris and form the structure named the *ligamentum pectinatum iridis*. Between these fibers are certain spaces called the *spaces of Fontana*, and these communicate with the anterior or aqueous chamber and with the canal of Schlemm, which has already been described.

Middle Vascular Tunic, Corneoscleral Junction, and Crystalline Lens.—Between the posterior surface of the cornea in front and the ciliary body, suspensory ligament, and crystalline lens behind, is the first important chamber of the eyeball, usually known as the *aqueous chamber*,

and which contains a clear watery fluid, the aqueous humor, which is "secreted" and supplied by the ciliary processes and their contained glands, and in part by the blood-vessels of the posterior surface of the iris. This chamber is divided into two portions by the iris, which, attached at its ciliary border, but elsewhere loose and resting lightly at its pupillary margin against the capsule of the lens, is perforated by a circular aperture near its center, known as the *pupil*, which establishes a communication between the two chambers thus formed, the anterior being the space described above, and the posterior the space between the posterior surface of the iris and the anterior surface of the crystalline lens and suspensory ligament.

The iris is divided into five layers, its greater portion, or vascular stroma layer, consisting of connective tissue rich in blood-vessels and of nerves and muscular tissue. The pupil is surrounded by an annular band of fibers, known as the *sphincter of the pupil*, which is in contact with the lens-capsule. Posteriorly a layer of radially placed fibers represents the *dilator of the pupil*.

Behind the iris is continuous with the ciliary body; in front it joins the posterior limiting membrane of the cornea through the pectinate ligament in the manner already described. The ciliary border of the iris is at least 3 mm. behind the apparent rim of the cornea, as one views this from the front—a fact to be remembered in operations on the iris (see page 878). At its point of attachment it is loosely adherent, and may be readily detached during operative interference, or as the result of blows.

Where the tissue of the sclera merges into that of the cornea is *the corneoscleral junction*, and at this region there is a union of the cornea, sclera, iris, and ciliary body. The manner in which the iris and cornea join through the pectinate ligament has been described, as has the circular venous channel surrounding the limbus of the cornea, known as the canal of Schlemm. The intraocular fluid which is concerned with the nourishment of the vitreous and the lens and which supplies the aqueous chamber is secreted by the epithelium of the ciliary body. The chief stream of this fluid proceeds over the lens and through the pupil into the anterior chamber, traverses the latter to reach the angle which is formed by the junction of the tissues already described, and there passes through the meshes of the pectinate ligament, and by diffusion and filtration is taken up by Schlemm's canal. From this canal the greater quantity of the fluid passes into the anterior ciliary veins, a small portion of it only being absorbed and eliminated by the iris. There is also a limited backward flow through the vitreous of this same fluid, and an escape by way of the perivascular lymph-channels in the optic nerve. It has already been pointed out that the intraocular pressure is equivalent to a column of mercury 25 mm. in height, and it remains within its physiologic limits only if nothing disturbs the regulation of the tension. Should the pressure in the ocular chambers rise above the physiologic limits, glaucoma results (see page 880).

Directly behind the iris lies the *crystalline lens*, a biconvex body

incased in a hyaline elastic capsule, which is somewhat thicker anteriorly than it is posteriorly, and which is held in position by its suspensory ligament, which passes from its capsule near the equator all around to the surrounding ciliary processes. Against its capsule in front rests the iris. Posteriorly the lens occupies a cup in the front of the vitreous, and the entire crystalline body is bathed in the aqueous humor. The lens is about 9 mm. from side to side and 4 mm. thick. In adult life it is composed of a harder central part, known as the *nucleus*, and a surrounding soft matter, which is called the *cortex*. The suspensory ligament of the lens is formed partly of thickened portions of the hyaloid membrane and partly of fibers derived from the folds of the ciliary region.

Between the attached or ciliary border of the iris anteriorly and the choroid coat posteriorly is the middle portion of the vascular tunic of the eye, known as the *ciliary body*, which is composed of two important portions, the *ciliary muscle* and the *ciliary process*. The ciliary muscle lies behind the corneoscleral junction, and in cross-section appears as a triangular band of muscle fibers which are both meridionally and circularly placed. The meridional fibers arise from the sclera and are inserted into the choroid, while the circular fibers surround the attached margin of the iris (see page 855).

Upon the internal surface of the ciliary body are about seventy irregular projections, known as the *ciliary processes*, to which are attached the fibers of the suspensory ligament of the crystalline lens. The ciliary body has a rich supply of blood-vessels and nerves, and the ciliary processes are composed of a connective-tissue stroma, pigment, and numerous blood-vessels.

The posterior portion of the uveal tract, or middle or vascular coat of the eyeball, is the *choroid*, which is a densely pigmented, highly vascular layer which lies between two non-vascular striæ, the former being the *suprachoroidal membrane*, lying directly beneath the sclera, and the other the *vitreous lamina*, which separates it from the retina. The intervening tissue is composed of numerous smaller and larger blood-vessels, elastic fibers, pigment cells, and endothelium. It joins the ciliary body in front, which body, indeed, by means of the tensor choroideæ, is inserted into it. It, like the ciliary body, is largely concerned with the nutrition of the eyeball.

From the surgical standpoint this membrane is important on account of the frequency with which various forms of sarcoma and endothelioma are developed in it, necessitating enucleation of the eyeball and sometimes evisceration of the orbit.

The Inner Tunic.—The inner nervous tunic of the eye is the retina, which morphologically extends from the entrance of the optic nerve to the pupillary margin of the iris. That portion which lies between the optic nerve entrance and the ciliary body, and which is situated between the choroid and the vitreous, is the portion of the membrane which is especially related to the function of vision. At the ciliary body the retina proper terminates in an irregular line, the *ora serrata*. The retina proper is a highly evolved and complicated structure, which from the histologic

standpoint is divided into three layers: (1) The layer of the neuro-epithelium, composed of two strata, namely, the layer of the rods and cones and the external nuclear layer, the former constituting the specialized outer portions and the latter the nucleated bodies of the visual cells. (2) The layer of the bipolar cells, which by some authorities are looked upon as the peripheral visual neurons. (3) The layer of the ganglion cells. The long processes, or axons, of these cells pass into the nerve-fiber layer of the retina, reaching the papilla or nerve-head, and proceed to the optic nerve. They constitute the only retinal layer which is directly continuous with the intraocular end of the optic nerve.

The entire eyeball is filled with a colorless, jelly-like mass, known as the *vitreous*, in its turn inclosed in a structureless membrane called the hyaloid. This membrane, as we have already seen, is in contact in front with the posterior capsule of the lens and with its suspensory ligament, which, indeed, is in part a development from it. The knowledge of these relations is important in cataract extraction (page 866). It is also in contact with the inner surface of the ciliary part of the retina, with the retina proper, and with the optic papilla. The vitreous, filling approximately four-fifths of the capacity of the eyeball, holds in place the retina, and hence after wounds of the eyeball involving much loss of vitreous, retinal detachment is apt to occur.

The Eyelids and Conjunctiva.—The eyelids are composed of skin, subcutaneous tissue, the orbicularis palpebrarum muscle, the palpebral ligaments, the orbitotarsal ligament, the tarsal plates, numerous glands, notably the Meibomian glands, vessels and nerves, and their under surfaces are lined with conjunctiva.

The skin of the eyelids is notable for its thinness. It is often somewhat darker than the surrounding skin, particularly that of the under lid. The superficial fascia contains no fat except in its periphery. Beneath it is a delicate areolar tissue. The lids are readily swollen and infiltrated with blood, and under certain circumstances with air. The shape of the lids is largely maintained by the *tarsal cartilages*, a misnomer in so far as the word cartilage is concerned, inasmuch as these structures are stiff plates of dense connective tissue and are entirely free from cartilage cells. The breadth of the upper tarsus is 9 mm., of the lower 4 mm., and the length of each about 20 mm. The tarsi are thickest in their center, thinning off at each end, where they join the *outer* and *internal palpebral ligaments*.

By a thin aponeurosis the *levator palpebræ superioris muscle* is inserted into the upper border of the superior tarsal cartilage. This muscle is above the superior rectus, and its upper surface is in relation with the frontal nerve and the supraorbital artery. It is innervated by the oculomotor or third nerve. The levator widens into an expansion which spans the whole of the orbit from one wall to the other, and which separates the larger or true lachrymal gland from its accessory portion below it. This expanded portion of the levator is divided into two layers, and the greater portion of it, which is inserted into the upper part of the tarsus, contains the involuntary muscle-fibers of Müller, the *superior palpebral*

muscle, the function of which is to draw the skin of the lid to the fold above the tarsus when the lids are opened. There are also involuntary muscle bundles of much less importance and development in connection with the inferior tarsus, which probably is also connected with fibers which proceed from the sheath of the inferior rectus; hence the drooping of the lower lid which sometimes is apparent after tenotomy of this muscle.

Continuous with the periosteum of the orbit are the *orbitotarsal fascias*, which are fibrous membranes extending from the superior and inferior orbital margins to the tarsal cartilages. The septum orbitale is a distinct membrane in the upper lid, but much more delicately constructed and less easily demonstrated in the lower lid. It fuses in the upper lid with the expansion of the tendon of the levator palpebræ superioris muscle.

The *external palpebral ligament*, which proceeds from the outer angle of the lids to the malar bone, is constructed by a thickening of some of the fibers of this membrane. It is a poorly developed tissue. On the other hand, the *inner palpebral ligament* is a strong band, which anatomically is the direct tendon of the orbicularis muscle, and which is readily demonstrated by drawing the lids outward, when it shows as a tense band beneath the skin to which it is attached. It proceeds from the internal ends of the tarsal ligaments to the superior maxillary bone in front of the lachrymal groove, and lies upon a portion of the septum orbitale, to which it is tightly attached.

Between the areolar tissue and the tarsal cartilages lie the fibers of the *orbicularis palpebrarum*, curving to be inserted by a tendon formed in the manner already described. Its function is to close the eyelid, and it is innervated by the facial nerve.

Of the numerous glands in the eyelids, the most important are the Meibomian glands, which are embedded in the tarsus, their ducts terminating at the margin of the lid, which is lubricated by their secretion. In addition to these, there are a number of other glands, for example, those at the free border of the lid, which are analogous to the sebaceous and sweat-glands of the skin elsewhere; also the modified sweat-glands of Moll, and in the neighborhood of the upper convexity of the tarsus small acino-tubulous glands (Krause's glands) which discharge their contents into the upper retrotarsal fold and are analogous to the lachrymal glands in structure. Reference is made to these because they are the starting-point of a number of growths which have their habitat in the lids and their contained structures.

The inner surfaces of the eyelids are lined by mucous membrane, forming the *palpebral conjunctiva*. To the tarsal portion of the lids this conjunctiva adheres closely, but beyond this point is freely movable, and beneath it there is a loose submucous tissue. After covering the under surface of the lids, the conjunctiva is continued over the front of the eyeball, where it receives the name of the *ocular conjunctiva*, and at the position at which it bends to pass from the lids to the globe it receives the name *fornix*. Passing over the globe, the conjunctiva

reaches the corneal border, where it blends with the conjunctival layer of the cornea. If it is carefully dissected from its position lining the lids and covering the front of the globe, and floated out into a single piece, it covers an area approximately the size of the palm of the hand. In health it is transparent, and its arteries, poorly developed, are derived from the palpebral and lachrymal branches of the ophthalmic, while those of the underlying episcleral tissue come from the anterior ciliary branches of the ophthalmic.

It is customary to divide the blood-vessel supply into three systems, namely:

(*a*) The posterior conjunctival vessels, whose congestion produces a bright red velvety color, moving on pressure of the eyelids with the shifting of the conjunctiva.

(*b*) The anterior ciliary vessels, composed of perforating and non-perforating arteries and veins. The former supply the sclerotic, iris, and ciliary body and are easily seen in health, entering about 5 mm. from the corneal margin, while the non-perforating branches are not visible in the normal eye, but under pathologic congestion produce the pink zone which surrounds the cornea when the iris and ciliary body are inflamed.

(*c*) The anterior ciliary vessels and the plexus surrounding the cornea, which are brightly injected when this tissue is inflamed.

Through the conjunctiva may be seen a series of vertical yellow lines over the tarsus, which mark the position of the Meibomian glands embedded in its substance. The separation between the margins of the lid when the eyes look straight forward is about 12 mm., the width varying somewhat with the movements of the eyeballs, being greatest when they are directed upward. At the union of the eyelids outward and inward are the canthi, at which position are the canthal ligaments already described. Just within the inner canthus there is a small, reddish prominence, the *lachrymal caruncle*, and between it and the eyeball a fold of conjunctiva known as the *plica semilunaris*.

The Lachrymal Apparatus.—The lachrymal gland (see also page 852) is composed of unequal parts, one above and the other beneath the tendinous expansion of the levator palpebræ. The upper or *superior lachrymal gland* reaches almost to the edge of the orbit. Its outer border passes nearly to the expansion of fascia from the external rectus, while its inner border extends to the outer edge of the superior rectus. It may readily be reached by an incision which passes through the eyebrow along the outer third of the orbital margin. The smaller division of the gland, or *inferior lachrymal gland*, is situated just behind the outer third of the upper fornix of the conjunctiva and extends as far as the external canthus. This portion of the lachrymal gland presents just above the outer canthus if, the eyeball being directed downward, the upper lid is everted and drawn upward and outward, and it may be readily reached and excised when it is thus exposed by incising its conjunctival covering.

On the margin of each lid near the inner canthus are two small eleva-

tions, the *lachrymal papillæ*, which contain minute apertures which lead into the *lachrymal canaliculi*, which extend from this position to the lachrymal sac. This sac lies in a depression in the lachrymal bone at the inner angle of the orbit. It is covered in front by the inner canthal ligament, but extends slightly above it. This relationship is important in the operation of removal of the lachrymal sac (page 923).

From the lower end of the sac passes the nasal duct, its direction being downward and slightly backward and outward. It lies in a bony canal whose periosteum forms its outer covering and terminates in the inferior meatus of the nose. The sac and nasal duct together constitute the lachrymo-nasal canal, which is lined with mucous membrane and which is about 24 mm. in length. When the sac is distended, its diameter is about 7 mm. and its length 12 mm. The greatest diameter of the nasal duct is about 4 mm.

PREPARATION OF THE PATIENT AND OF THE EYE FOR OPERATION.

In so far as the preparation of their hands, gowns, operating rooms, and surroundings is concerned, ophthalmic surgeons follow the strict rules of modern surgery, but inasmuch as the tissues involved in many of their operations are of exceedingly delicate structure, certain modifications in technic are necessary.

Preparation of the Skin of the Region of Operation.—The face, surface of the closed lids, eyebrows, brow and scalp, should be thoroughly washed with soap and water, next with alcohol, and finally with corrosive sublimate, 1:2000; the conjunctival sac may be freely irrigated with a bichlorid solution 1:8000. Subsequently the parts should be covered with a compress of lint soaked in the bichlorid solution until the time for operation arrives. For an operation which contemplates an incision into the globe of the eye—for example, the extraction of cataract—the technic must be more elaborate. For some days previous to the operation the margins of the lids, their surfaces, and the eyebrows should be frequently washed with soap and water and the conjunctival cul-de-sac irrigated with a saturated solution of boric acid or a sublimate solution, 1:5000. If, in spite of these precautions, bacteriologic examination demonstrates the presence of pathogenic organisms, the operation must be postponed until they have been made to disappear by suitable treatment.

During these days the nasopharynx should be frequently sprayed with Dobell's solution, or with a 1 to 3 solution of peroxid of hydrogen, or, following a recommendation of J. A. Lippincott, of Pittsburg, with a solution of permanganate of potassium, 1:5000. It is the custom of many surgeons to place upon the eye which is to be subjected to an operation a bandage during the night prior to its performance, which holds in place a small eye pad, which has been soaked either in a solution of boric acid or in a solution, 1:5000, of bichlorid of mercury. If on its removal any secretion is found upon the lashes or the overlying pad the operation is postponed until a perfectly clean pad is obtained. In

my experience this is not a useful procedure, as it tends to encourage conjunctival hyperemia.

A better method is that recommended by J. A. White, of Richmond, according to which on the night prior to the operation the conjunctival sac is filled with vaselin, which has been sterilized by boiling, and to which in the proportion of 1 : 3000 bichlorid of mercury is added. This bichlorid-vaselin should remain in the conjunctival sac until the following day.* If there is any discharge from the lachrymal sac, this structure must be brought into a healthy condition, and if dacryocystitis is present, the sac should be excised (see page 923), or the canaliculi may be tied by passing a thread beneath each one of them, in the manner recommended by the late Frank Buller.

To shave the eyebrows and to trim the lashes before an operation for cataract, or, following the recommendation of Hjort, to epilate the cilia, are unnecessary procedures. If blepharitis is present, the operation must be postponed until the condition is cured. Just prior to the operation the cilia should be carefully cleansed with a pledget of cotton dipped in a 1:5000 bichlorid solution, and the inner canthus and everted lids gently mopped with a cotton wad steeped in the same solution. Following this, the conjunctiva may be freely and somewhat forcibly irrigated with a tepid boric acid or physiologic salt solution, but strong solutions of bichlorid are not only unnecessary, but unwise. A precaution sometimes taken is to introduce the point of an Anel syringe into each punctum and gently irrigate the canaliculi, lachrymal sac, and lachrymal duct, with either a 1:5000 bichlorid of mercury solution, or a saturated solution of boric acid.

Preparation of Instruments.—All coarse instruments, such as hooks, spatulas, forceps, etc., should be sterilized in the usual manner in a small sterilizer. Delicate instruments, for example, cataract knives, even if carefully wrapped in cotton, are almost certain to be dulled by being boiled in water or placed in the usual sterilizing apparatus. Hence, Stroschein and others recommend as sufficient that they shall be rubbed with cotton-wool soaked in a mixture of equal parts of alcohol and ether, and subsequently washed in a solution of carbolic acid 1 : 20. Carbolic acid, although recommended by Haab and other distinguished surgeons, has not seemed satisfactory to me, and it is probable that the very sharp, delicate blade of a cataract knife can be perfectly sterilized by wiping it vigorously with cotton soaked in absolute alcohol.

A number of investigations, notably those by E. A. de Schweinitz, H. O. Reik, and W. J. Watson, indicate that formaldehyd is of practical value for disinfecting small instruments, and in the Massachusetts Eye and Ear Infirmary it is the practice of many of the ophthalmic surgeons to utilize this form of sterilization.

Dressings and Sutures.—The preparation of dressings and sutures

* White's formula is as follows:

Bichlorid of mercury	gr. j
Sodium chlorid	gr. v
Vaselin	℥vj

does not differ from that which applies to gauze, cotton, and bandages, used in ordinary surgical procedures. Either a single or double gauze bandage is usually employed, or a modification of Leibreich's bandage. Many ophthalmic surgeons place over an ordinary dressing composed of an oval of gauze and sufficient sterilized absorbent cotton to fill out the orbital space, a knitted bandage which is tied in place with tapes proceeding from each end. Certain special dressings suited to cataract extraction will be referred to on page 869.

Sutures may be composed of either catgut or silk prepared in the usual manner. I am of the opinion that catgut is not to be compared in usefulness to silk, even where the sutures are buried, as in the operation of implantation.

General Anesthesia.—The indications for general anesthetics in ophthalmic surgery are comparatively limited. They are necessary in most enucleations, in eviscerations, in many of the plastic operations, sometimes in advancements of the ocular muscles, and in many of the cases of glaucoma. The surgeon must decide between ether and chloroform, and although the latter has certain distinct advantages in ophthalmic surgery owing to the rapidity of its action and the lessened danger of nausea and vomiting, it is not so safe as ether, and therefore ether is to be preferred. Bromid of ethyl has been recommended, but I am not impressed favorably with this anesthetic. An excellent practice is to begin the anesthesia with nitrous oxid, and primary inhalation of ethylchlorid, which of itself is a suitable anesthetic in many short ophthalmic operations, is worthy of commendation.

Local Anesthesia and Analgesia.—For local anesthesia hydrochlorate of cocain still holds the first place. It may be employed in a 2 to 4 per cent. solution, and I have never seen the slightest advantage in the stronger solutions sometimes recommended. Its influence upon the corneal epithelium is a matter of some importance, and after it is dropped into the conjunctival cul-se-sac the lids must be kept closed between the instillations, or, as the investigations of Mellinger have shown, the drug may prevent closure of the corneal wound. Gelatin discs impregnated with cocain have no advantage over a solution of the drug. Haab recommends an application of a thin layer of cocain in crystals. Cocain solutions may with care be sterilized by boiling in specially prepared flasks; for example, those designed by Stroschein and their modifications by Sidler-Huguenin, or in the one designed by Llewellyn, of Philadelphia. The addition of antiseptics—for example, a 1: 5000 solution of bichlorid of mercury, or a 1 : 1000 of trikresol, to the solution of cocain—has also been recommended. Eucain, although it is an efficient anesthetic, produces congestion of the conjunctiva, and is not to be compared in value to cocain. It has the advantage, however, of not being decomposed by boiling, and is a useful drug for subcutaneous injection. Holocain in a strength of 1 per cent. produces local anesthesia in from fifteen seconds to one minute, and has the advantage over cocain of not enlarging the pupil or increasing intraocular tension. It probably possesses mild bactericidal qualities. Some surgeons prefer it to cocain. Acoin, a

drug related to caffein and theobromin, is an active local anesthetic in unirritated eyes, in a strength of 1: 100 or 1: 300. In congested eyes, however, repeated instillations do not produce satisfactory anesthesia. It is, however, a very useful anesthetic to add to solutions; for example, physiologic salt solution, or bichlorid of mercury solution when used in subconjunctival injections. Stovain in 4 per cent. solution produces some smarting and burning of the conjunctiva and develops a local anesthesia which lasts for about five minutes. It has no influence on the pupil and does not cause paresis of accommodation. As it is not decomposed by boiling, its sterilization is easy. My experience with it is a limited one, but it has not seemed to me to have any advantages over cocain. The glycerin derivative, alypin, in 2 per cent. solution, causes a local anesthesia, but creates a dilatation of the superficial vessels and its instillation is followed by smarting. It does not dilate the pupil and has no influence upon accommodation, but is not as satisfactory as cocain. With tropacocain I have had no experience.

Other local anesthetics, for example, peroin and yohimbin, are interesting as pharmaceutic compounds, but have no advantage in local anesthesia. Dionin is a lymphagog and an analgesic. It is not an anesthetic, and has no place in operative work, although it is of great importance in the treatment of many ocular diseases.

Infiltration Anesthesia.—In many of the lid operations satisfactory anesthesia can be produced by injecting a 2 to 4 per cent. solution of cocain beneath the skin, or, still better, a solution of eucain beta. The so-called infiltration anesthesia as recommended by Schleich, and which is elsewhere described, is also available. Better than all of the mixtures is one composed of eucain beta, to which a certain amount of adrenalin chlorid is added; Barker's recently recommended solution, in my experience, being especially efficacious. It is composed as follows:

Pure sodium chlorid	0.8	gm.
Beta eucain	0.2	"
Adrenalin chlorid	0.001	"
Distilled water	100.0	"

Not only may a solution of this character be used in plastic operations about the lids, but it can be employed in the operation of enucleation. The conjunctiva is anesthetized with cocain in the usual manner, and a few drops of the adrenalin-eucain solution, which is still further enhanced in value if cocain is added to it, are injected by means of a long, sharp-pointed syringe along the course of each of the four recti muscles.

Local Hemostasis.—Various preparations of suprarenal capsule are employed for local hemostasis, the best of them being adrenalin chlorid, which is efficient in a solution of 1 : 10,000. It is useful in minor operations; for example, the removal of a pterygium, or the tenotomy of an ocular muscle. As the drug may be added to the ordinary cocain solution, the instillation of the mixture produces at once a blanching of the tissues as well as a local anesthesia.

OPERATIONS ON THE EYEBALL.

Operations for the Extraction of Senile Cataract.—Cataract, an opaque condition of the crystalline lens, is called *cortical*, if the opacities radiate from the periphery toward the center, and *nuclear*, if the opacity includes and surrounds the nucleus. The period of growth of a cataract from incipiency to full maturity ordinarily consumes from one to three years, but the rate of increase may be exceedingly slow, and a cortical cataract may remain immature for years.

A complete cataract is usually gray-white in color, sometimes white or amber, and rarely black. The nucleus, which itself does not become cataractous but is hardened, is yellowish or brownish in color. If, after full dilatation of the pupil, illumination of the pupillary area causes no shadow of the iris to appear as a dark semicircle on the opacity at the

FIG. 456.—INSTRUMENTS REQUIRED FOR CATARACT EXTRACTION.
a, Eye speculum; *b*, fixing forceps; *c*, curved iris forceps; *d*, metal spoon; *e*, wire loop; *f*, cystotome; *g*, cataract knife; *h*, capsule forceps.

side from which the light comes, and if illumination with the ophthalmoscopic mirror reveals no red reflex and no shining sectors are visible, the cataract is mature and is said to be "ripe."

Ordinarily it is best to wait for maturity before operating, but after the sixtieth year of life a cataract may be extracted even if some portions of the cortex have not yet fully matured, provided the lens is not in the stage of swelling. Before undertaking an operation, examination must be made to ascertain if the interior of the eye is in a reasonably healthy condition. For this purpose the patient is placed before a lighted candle, about 2 meters distant. The flame should be distinctly recognized. While the eye attentively fixes the flame, a second lighted candle should be moved radially through the field of vision. The patient should be able

to recognize the flame as soon as the rays strike the edge of the cornea, and should be able to indicate the direction from which the light is coming. If the answers are accurate and if the patient's physical condition is satisfactory and the eye and its surroundings are free from disease and sources of infection, the cataract may be extracted.

(a) **Extraction without Iridectomy, or Simple Extraction.**—The following instruments are required: A stop speculum, a fixation forceps, a lid elevator, a spatula, a wire loop, a spoon, an olive-tipped probe, a curet, a cystotome, capsule forceps, a pair of iris scissors, iris forceps, and a cataract knife (Fig. 456). The patient and eye having been prepared according to the method already described (page 861), and the eye having been anesthetized with three drops of a 4 per cent. solution of cocain, instilled at five-minute intervals (if preferred, a 2 per cent. solution of holocain may be substituted), and the patient having been placed upon a suitable operating table or operating chair, and the field of operation illuminated, either from a window by daylight, all shadows being eliminated, or artificially by means of a hooded electric light, the surgeon, if ambidextrous, stands behind the patient, no matter which eye is to be operated upon. If not, he takes this position for the right eye only, but stands at the patient's side and in front for an operation on the left eye. The speculum having been inserted, the surgeon steadies the eyeball, draws it downward with the fixation forceps by taking firm hold of a fold of conjunctiva below the inferior border of the cornea, and enters a Graefe cataract knife exactly at the corneoscleral junction at the outer extremity of a horizontal line which would pass 3 or 4 mm., according to the size of the cataract, below the summit of the cornea, passes the knife across the anterior chamber to a corresponding point upon the opposite side, and makes a counter-puncture (Fig. 457). Next, the knife is pushed steadily onward as far as possible with an upward tendency, and the incision is completed by a free cutting, not sawing or dragging, movement, while the knife is kept in the same plane throughout, and its edge is not turned at the completion of the section either forward or backward. By this maneuver a small conjunctival flap is cut. If this is not desired,

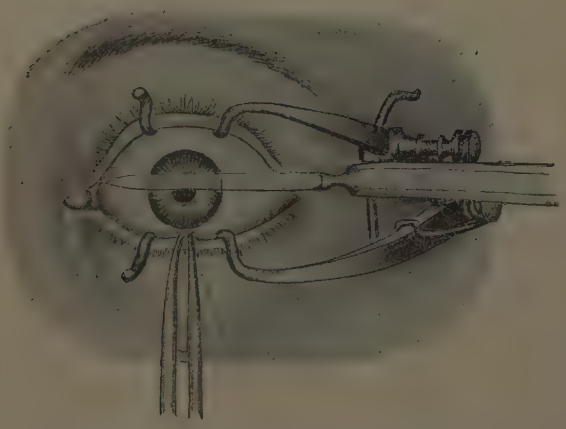


FIG. 457.—THE INCISION IN CATARACT EXTRACTION.
Puncture and counter-puncture have been made. The section will pass in its whole extent exactly through the transparent margin of the cornea, the knife remaining in the same plane throughout.

when the summit of the cornea is reached, the knife must be turned a little forward before the completion of the flap. This terminates the first stage.

In the second stage the capsule of the lens is opened. The surgeon draws the eyeball slightly downward with the fixation forceps, and with the cystotome held flatwise during its insertion, but turned with its cutting-edge toward the capsule as soon as the surface of the iris is passed, incises the capsule in such a manner that the limbs of the incision are like those of an inverted letter A, the transverse cut being made at the periphery. A small, triangular opening results which is directly in front of the pupil space. If the capsule is opened in its extreme periphery, as Knapp and other surgeons prefer, an operation for after-cataract will later be necessary. In place of opening the capsule with a cystotome, some surgeons always employ the capsule forceps, with which a small portion of the anterior capsule directly in front of the pupil is seized and isolated from its position. This is a good method if the anterior surface of the capsule happens to be thickened. It is particularly advocated by Eugene Smith in this country and by Treacher Collins in England.

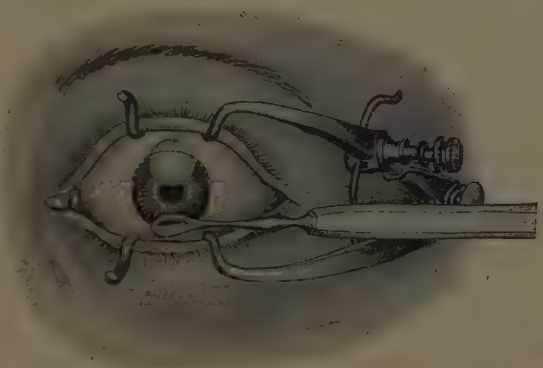


Fig. 458.—The Delivery of the Lens.
The lens is presenting in the wound (capsulotomy has been performed).

In the third stage the cataract is delivered, as follows: The patient is required to look downward, or if he is not readily controlled, the eye is gently drawn downward by means of the fixation forceps. Next the speculum should be removed and the upper lid held away from the incision by means of a lid elevator, or else an assistant should raise the speculum so that its blades shall not press upon the eyeball and yet shall lift the lids away from the eye. The convex surface of a metal spoon is now laid against the inferior portion of the cornea, and firm but gentle pressure is made, which causes the upper margin of the lens to appear in the pupil space. As the cataract slips through the pupil into the wound the spoon is made to follow it with a gentle upward movement which delivers the lens and at the same time removes small fragments of cortex (Fig. 458). Next, the conjunctival flap, if this has been cut, is smoothed out by introducing the end of a polished grooved spatula into the anterior chamber and passing it through the wound from one end to the other. This will remove any particle of lens or capsule which may be adherent to the wound, and adjusts the iris. If the iris does not spontaneously recover its natural position it can usually be made to assume its proper place by

pressing slightly upon the lower portion of the cornea. If this fails, the iris should be pushed back with the spatula into the anterior chamber, but if it tends to ride up into the wound, or the pupil does not become perfectly circular, a small iridectomy should be made. If the cataract is thoroughly ripe, it frequently comes out cleanly and no cortical remnants are left behind. If small pieces of cortex remain, they should be carefully removed by gently stroking the cornea with the back of a metal spoon until they appear at the margin of the wound, where they are wiped away with a polished probe.

In place of this maneuver, some surgeons are accustomed to irrigate the anterior chamber by means of a specially devised syringe, the one designed by Lippincott, of Pittsburg, being specially advantageous. The fluid used for this purpose is physiologic salt solution, which is tepid, and which should be gently allowed to flow into the anterior chamber and flush out cortical remnants. It aids also in the reposition of the iris. In my opinion irrigation of the anterior chamber in ordinary senile cataract extraction is rarely necessary, although it may be a valuable adjunct in other forms of cataract extraction and during certain complications which will be mentioned later.

(b) **Extraction with Iridectomy, Often Called Combined Extraction.**—In the first stage the maneuvers already recorded are repeated.

In the second stage an iridectomy is performed, as follows: The fixation forceps are entrusted to an assistant, who gently draws the eyeball downward, while the operator takes in his left hand the iris forceps and in his right hand the iris scissors. The blades of the iris forceps are gently introduced between the lips of the wound and a small portion of the iris seized midway between the pupillary and the ciliary border, and the tissue drawn out and toward the cornea and cut off with one or two snips of the scissors close to the corneal border. (See Fig. 462.) It is not necessary to make a large coloboma, nor, indeed, is it necessary, if the patient is docile, that the eyeball shall be held during the performance of this operation. The patient is simply required to look downward. The pillars of the coloboma are now carefully smoothed with a delicate spatula, great care being taken to free any iris tissue which may have become entangled in the angles of the wound, so that the iris shall be perfectly in place and the coloboma straight and clear.

The third stage is the same as that which has already been described during which the capsule is opened, and the same may be said of the fourth stage, or that of delivery of the cataract, during which, however, the manipulations are much more easily performed than they are when simple extraction is undertaken, the delivery of the lens through the coloboma being more easily effected than the delivery of the lens through the circular pupil, especially if the sphincter of the iris happens to be rigid. So, too, cortical remnants, blood-clot, and débris are more readily expelled; in short, the toilet of the wound is more easily performed.

The *dressing* after any form of cataract extraction, in my opinion, should consist of an oval piece of soft lint soaked in a solution of bichlorid of mercury, 1 : 5000, laid upon each closed lid. Over this is

placed a similarly shaped piece of sterilized cotton, large enough to be flush with the eyebrow and lower margin of the orbit, which is held in place with three narrow strips of surgeon's ising-glass plaster. During the first night or two after the operation the dressing may be covered with some form of protection, for example, an ocular mask, or an aluminum shield or a wire cage. (See Fig. 459.) At the end of twenty-four hours, if the operation has been performed without iridectomy, the eye should be inspected. If the iris is in place and the pupil round and the anterior chamber closed, one drop of a sterile atropin solution, 4 grains to the ounce, should be instilled. If the anterior chamber is not reformed, but the iris is in place, the dressings should be reapplied without the introduction of the atropin. If the iris is prolapsed into the wound, it should be abscised in precisely the same manner as an iridectomy is performed, and it may be necessary in nervous patients to use a general anesthetic for this purpose.

Fig. 459.—Ring's Ocular Mask.

If the operation has been performed according to the combined method, and there has been no pain and there is no swelling of the lid, the eye need not be inspected until the end of the second day, when the anterior chamber is usually closed, and the dressing may be renewed after the instillation of a drop of atropin solution. If all goes well, the unoperated eye may be liberated at the end of the third day, and usually by the end of the sixth day the dressing from both eyes may be removed and the eyes shaded and protected with colored glasses, except at night, when a light dressing should be applied and should be continued until the end of the second week. Some surgeons apply no dressing after cataract extraction, but protect the eye simply with a shield or wire cage. This is the so-called "open method," with which I have had no experience, but the safety of which I doubt, in spite of its distinguished advocates.

At the expiration of six weeks to two months, cataract glasses may be adjusted. The correcting lens for distant vision is usually about 11 D. For reading and similar occupations a lens having a focal distance of 25 to 33 cm. must be added to the distance glass. If the eye has been hyperopic prior to the operation, a stronger lens than the one indicated may be required, while if it has been myopic a weaker one; indeed, it is possible to produce by the operation emmetropia, if the former near-sightedness has been of such degree that the removal of the lens exactly neutralizes it. Usually, and especially during the earlier months after cataract extraction, there is a good deal of astigmatism, but in a technically correct operation usually not more than 1½ or 2 D. remain permanently. This, however, should be corrected and the cylindric glass incorporated with the spheric lens.

Accidents During Operation and Anomalies in the Healing Process.—If during the passage of the knife across the anterior chamber the iris should fall in front of it, the incision should be completed in the manner already described, with the result that an irregular coloboma will be cut, which later may be remedied by seizing its jagged edges with the iris forceps and trimming them with scissors.

Occasionally, especially if a conjunctival flap is made, or during the performance of iridectomy, there is free hemorrhage into the anterior chamber, obscuring the field of operation. Usually the blood will cease to flow on the exertion of slight pressure, and by gently stroking the lower portion of the cornea it may be expelled from the anterior chamber. If this maneuver fails, the cystotome must be introduced in the ordinary manner, the capsule lacerated, and the lens delivered, which in the process of its expulsion will often carry with it a sufficient amount of the blood to clear the pupil space. Even if this does not occur, the blood is usually rapidly absorbed during the first twenty-four hours.

Undue pressure of the cystotome may effect a partial or complete dislocation of the lens, and if it cannot be promptly delivered, the wire loop must be introduced behind it and the lens delivered by a gentle traction movement. If by awkward manipulations, or as the result of disease, the hyaloid membrane is ruptured, vitreous will present in the wound and sometimes escapes with great freedom. Should this occur before the lens is delivered, the speculum must be quickly removed and the wire loop gently inserted behind the lens, which is then removed by means of it. If the vitreous escapes after the lens has been extracted, it should be removed from between the lips of the wound as rapidly as possible, a bandage applied, and the patient kept perfectly quiet. After great escape of the vitreous, the partially collapsed eye should be filled with a tepid, sterile, physiologic salt solution, which is injected into the vitreous chamber until the eyeball assumes its proper contour. In elderly persons, and particularly if cocain has been used too freely, after the delivery of the lens there may be great collapse of the cornea, so that this membrane assumes a concave shape. The anterior chamber should be filled, as Knapp recommends, with sterile physiologic salt solution, which aids in making proper coaptation of the lips of the wound and thus prevents sucking in of conjunctival juices.

If capsulotomy has been imperfect, or if the capsule is exceedingly tough, it is sometimes impossible to deliver the lens in the ordinary manner. The capsulotomy must be repeated, or a piece of the capsule must be removed with capsule forceps, or the lens must be delivered in its capsule by the introduction behind it of the wire loop in the manner already described.

Ordinarily there is little discomfort after a normal cataract extraction. Decided brow or temple pain occurring within a few hours after the operation always means some serious complication; intraocular hemorrhage, suppuration of the wound, and iritis are most to be dreaded.

Intraocular hemorrhage usually begins soon after the operation and is presaged by pain in the head, nausea, and sometimes by vomiting. On removal of the bandage, a clot of blood will be found between the lips of the wound; sometimes the hemorrhage is so free that it stains the bandage or runs down upon the face. The patient should be placed in the semi-upright position, a hypodermic of morphin administered, the blood-clots removed, and a firm, though not tight, compress bandage applied, after thorough irrigation of the conjunctival sac with a tepid bichlorid solution, 1 : 10,000. If the hemorrhage has come from the choroidal vessels and is an expulsive one, the eye is invariably lost. If it comes from the vessels of the iris or ciliary body, prompt treatment will sometimes avert entire loss of the eye. If the hemorrhage is repeated, or if infection should occur, enucleation is required.

Suppuration of the wound is comparatively rare, but in spite of all precautions occurs in a certain number of cases, according to Knapp in about 1 per cent., although this is a higher percentage than recent statistics and experience indicate. Usually it begins from the first to the third day, more rarely after the fifth day, but it has been delayed as late as the thirteenth day. The symptoms are great pain, swelling of the lids, chemosis of the conjunctiva, and sloughing of the margins of the wound. Prompt treatment—that is to say, thorough antisepsis of the eye, cauterization of the line of the wound with the galvanocautery or with carbolic acid, and daily opening and draining of the anterior chamber—will occasionally avert a general panophthalmitis. In recent times, following the recommendation of Haab, small rods of sterilized iodoform have been introduced under these circumstances into the anterior chamber. In my opinion, however, they do not furnish a very satisfactory method of treating this complication. Some surgeons (Hansell) recommend the introduction of bichlorid of mercury directly into the anterior chamber, and others subconjunctival injections of bichlorid of mercury, 1 : 5000, or of cyanid of mercury in similar strength. If the treatment fortunately stops the process in the cornea, the iris becomes drawn up and the pupil closed with plastic lymph. Later, a secondary operation, in the form of either iridotomy or iridectomy, may restore some vision. If the infection manifests itself in the form of a ring abscess, or begins in the vitreous or in the iris, the process is usually a rapid one, and the eye is lost by an extensive panophthalmitis, in spite of all treatment.

Iritis and iridocyclitis occasionally appear, generally not before the fifth day, although sometimes they are delayed until the tenth or twelfth day. If the process is limited to the iris, the vigorous use of atropin and dionin and the internal administration of salicylate of sodium and the iodid of potassium are usually followed by satisfactory results. If the ciliary body is extensively involved, especially if there is a late iridocyclitis, which continues to relapse in spite of all treatment and which often gives rise to secondary glaucoma, the prognosis is extremely gloomy. If ultimately the process is checked, the pupil will be closed by lymph

and the visual results vitiated unless the eye becomes sufficiently quiet to permit of the operation of iridotomy or iridocystectomy.

Either as the result of iritis, or sometimes without any apparent involvement of the iris, glaucoma sometimes supervenes, and depends upon some closure of the filtration angle, generally as the result of imperfections in technic and obstructions caused by remnants of capsule or iris, and sometimes, as Elschnig's investigations show, by reason of a proliferation of epithelium within the anterior chamber. The symptoms are great pain, steaminess of the cornea, and rise of intraocular tension. If the condition of affairs cannot be controlled by the instillation of myotics, that is to say, either pilocarpin or eserin, an iridectomy or a sclerotomy should be promptly performed.

Prolapse of the iris after simple extraction occurs in from 3 to 10 per cent. of the cases. It causes a sharp pain, and often results from a traumatism or violent exertion, for example, a fit of coughing. On inspection the iris will be found to have separated the lips of the wound and to be protruding between them. If it is seen soon after the accident, the protruding iris should be abscised and every endeavor made to obtain a clean wound and good coaptation of its edges. If the iris-prolapse has not been a large one and it is not seen immediately after its occurrence, it is sometimes proper to treat it by the expectant method, that is, by a compressing bandage, until the eye is quiet, when the slight staphylomatous protrusion may be abscised. At one time it was the custom to instil eserin after prolapse of the iris, in the hope that it would draw this tissue back again into the anterior chamber. This practice has been largely abandoned owing to the irritating nature of most of the myotics.

Ordinarily a cataract wound is closed at the end of twenty-four hours. Occasionally there is slow closure of the wound, almost always due to some foreign substance, for example, a bit of capsule or cortex which has remained between the lips of the wound. If this can be found, it should be removed. If the slow closure depends simply upon lack of reparative power on the part of the patient, the lightest possible dressing should cover the eye, which should be kept as strictly clean as possible to prevent infection, and generally after a time the chamber will be restored. It may be necessary lightly to cauterize the entire length of the wound before this restoration occurs. For this purpose a pointed stick of nitrate of silver may be drawn gently along its entire length.

Post-operative insanity after cataract extraction in mild degree is not uncommon. It may appear in violent manifestation. It must be treated on general principles, the various hypnotics usually being required.

Other Methods of Extracting Cataract.—Numerous modifications of the incisions already described for the purpose of extracting cataract have been designed, and for their consideration the reader is referred to systematic works on ophthalmic surgery. To one attention should be drawn, as it has attracted much interest within recent times, namely, *extraction of the lens without capsulotomy*,—that is, in its capsule,—originally suggested by Pagenstecher, who, after an iridectomy and the usual although somewhat larger corneal incision, delivered the lens in its

capsule with a loupe or specially devised curet. A modification of this operation is practised by certain Indian surgeons, notably by Major Henry Smith, who after a liberal-sized upper incision, by systematic pressure, carefully and persistently used, delivers the lens without rupture of the capsule. Theoretically this is an operation which should yield the best results, as it eliminates the necessity of dealing with that operation which is suited to the formation of after-cataract. It is surrounded, however, by many difficulties, notably, the danger of the escape of vitreous, and although advocated by Major Smith as the operation of election, has been condemned by other surgeons.

Extraction of a cataract before it is ripe is necessary under certain circumstances, and if there is not too much clear cortex, in patients who have passed the sixtieth year of life, often yields excellent results equal in value to those obtained after the lens is ripe, the chief difficulty being concerned with the toilet of the wound and the danger of leaving behind fragments of cortex which by swelling may produce the various forms of iritis and iridocyclitis. In order to avoid this, certain surgeons systematically wash out the anterior chamber in the manner already described (page 868).

In place of waiting for ripening, some surgeons are accustomed to perform a *ripening operation* preparatory to the extraction of an incomplete cataract. There are many methods, the best known of which is the so-called Förster method, in which after an iridectomy the lens capsule is stroked by means of a blunt spatula, which causes an increase in the opacification. At the expiration of four to six weeks the cataract is extracted in the usual manner. A similar ripening process has been induced by deep discission of the lens (Schweigger's method), by division of the capsule combined with iridectomy (Mooren's method), by a paracentesis of the cornea and internal massage applied directly to the capsule with a small spatula (Bettman's method), and by simple paracentesis of the cornea with external massage (Pooley and White's method). In my opinion these ripening operations are not as satisfactory in their results as extraction of the incomplete cataract in the ordinary manner. The best results are reached by not interfering surgically until nature has itself ripened the cataract.

Extraction of the clear crystalline lens is practised for the neutralization of high and progressive myopia (Fukala's operation), usually preceded by a discission with a needle, in the manner presently to be described, and followed either by a formal extraction of the lens or by a linear or suction operation (page 875).

Operation for After-cataract, So-called Secondary Cataract, by the Method of Discission.—The lens capsule which remains after the extraction of the crystalline body may be sufficiently thin, and the original opening sufficiently clear, to render further interference unnecessary. In a goodly percentage of the cases, however, *after-cataract*, sometimes called *secondary cataract*, forms, which depends upon a proliferation and thickening of the capsular epithelium and upon agglutination of the two layers of the capsule, or upon the development of new-formed tissue

between the capsule layers, especially if the case has been complicated by inflammatory processes. Under the last-named circumstances the tissue may be so thick that the term *membranous cataract* is applied.

The operation of discission for after-cataract is performed as follows:

The pupil must be dilated ad maximum and the area of operation perfectly illuminated, and a knife-needle entered either 3 mm. within the corneal margin or at the corneoscleral border, and the instrument advanced to a point close to the opposite margin of the iris, where the membrane is punctured and a horizontal incision is made, 4 to 5 mm. in length. Next, the point of the instrument is raised toward the cornea and passed upward in front of the membrane, which it transfixes at a point 2 mm. above the horizontal incision, and divides it by a cutting movement downward as far as the original transverse cut. The same procedure is repeated on the lower half of the membrane, cutting from below upward. The result is a crucial incision, the edges of which retract, and a good central aperture in the membrane is thus obtained (Fig. 460). The subsequent treatment is precisely the same as that which has been described in connection with the original operation.

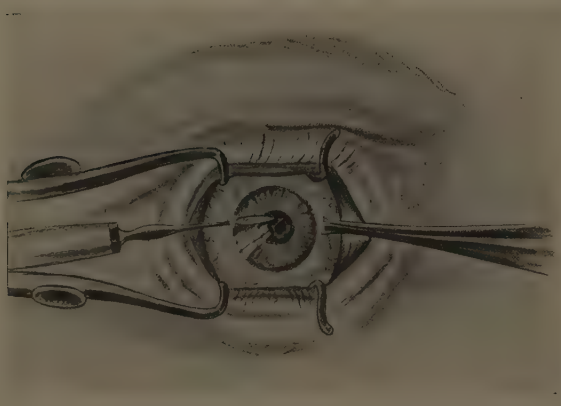


FIG. 460.—OPERATION FOR AFTER-CATARACT (after Haab).

This procedure is subject to the same dangers which surround a formal extraction of cataract, notably, iritis, iridocyclitis, infection, and glaucoma, and the greatest care must be taken that during its performance the knife-needle shall cut and not drag upon the membrane. If either iritis or iridocyclitis should supervene, the treatment already described must be instituted. If glaucoma, evident by an increase in intraocular tension and steaminess of the cornea, should arise, myotics, either eserin or pilocarpin (1 to 2 grains to the ounce), must be used, and if they fail, the tension must be reduced by an iridectomy or a sclerotomy.

If the cataract is a membranous one, or if the pupil has been closed by inflammatory deposits, the knife-needle operation cannot be employed, and in its place some form of operation which approaches in its character an iridectomy is necessary. The one often employed is that named by De Wecker *iritoectomy*, in which a triangular knife is thrust through the corneoscleral border and directly downward through the tense membrane which closes the pupil. It is next withdrawn, and a pair of delicate scissors is introduced through the cut into the membrane in such a manner

that one blade lies behind this tissue and another one in front of it, and converging cuts from each end of the original transverse incision are made, which meet at an apex at the bottom of the pupil. The piece of tissue included between these three incisions is removed with forceps, and if successful, a good triangular opening results. The operation is difficult and dangerous, and is often accompanied by loss of vitreous. Many modifications of this operation have been designed, for which systematic treatises on ophthalmology must be consulted. Instead of using scissors, a Hays knife-needle may be employed to cut the flap, as advised and practised by Lewis Ziegler. In place of excising the piece of capsule, the operator may succeed by making a transverse cut through the thickened membrane, which, being elastic, retracts. This is an *iridotomy*—a name also given to the more formal procedure with scissors.

Operations on Congenital and Soft Cataract.—Juvenile or congenital cataract is either a complete or a partial opacity of the lens. If complete, it is soft, that is, there is no distinction of nucleus and cortex; if incomplete, it usually appears in the form of an opaque layer surrounding the clear but sometimes cloudy center of the lens, and is known as *zonular* or *lamellar cataract*. The following operations have been designed for the relief of this condition.

(a) Operation on Congenital Cataract by the Method of Discission.—The pupil being widely dilated, a knife-needle, or one provided with a shoulder, known as a Bowman's stop needle, is introduced at the corneoscleral junction and made to penetrate the capsule of the lens, which is divided in a crucial manner, and not too deeply at the first attempt. This admits the aqueous, which by its dissolving action either renders completely opaque an incomplete cataract, or begins the solution of one that has been originally complete. Usually it is necessary to repeat this discission, and at the subsequent operations it may be more extensive, two or three times before there is complete solution of the opaque lens fibers. After each operation the eye should be bandaged, its pupil kept dilated with atropin, until all reaction has disappeared. From three to six months may be required before there is complete solution. The same dangers and complications surround this operation which have been previously described, and if they occur should meet with the same treatment. (Consult page 871.)

(b) Operation by the Method of Linear Extraction.—In place of repeated discissions, or sometimes in the case of complete soft, congenital cataracts, or complete juvenile cataracts, which have appeared before the thirtieth year of life, the lens may be removed by the method of linear extraction, as follows:

The pupil being widely dilated, a keratome is introduced at a point 1 mm. within the margin of the cornea and thrust onward until a wound 5 mm. in width is made. The instrument is now carefully withdrawn by means of a slight lateral motion, and a sharp cystotome introduced and the capsule of the lens freely lacerated. The soft lens matter is next extruded by counter-pressure on the cornea with a metal spud, the outer lip of the corneal wound at the same time being depressed with a curet.

All manipulations must be exceedingly gentle, lest the hyaloid is ruptured and vitreous escapes.

This operation is suited to the extraction of any soft cataract, to some forms of traumatic cataract, to those varieties of cataract which have been treated by discission and in which it is not desired to repeat the discission until solution is accomplished, or in which the discission has been followed by rapid swelling of the lens and inflammatory or glaucomatous symptoms on account of the pressure on the surrounding ciliary region. It is also the method employed to extract the clear lens after it has been broken up by a deep discission in that operation which is used for the relief of high myopia. (See page 873.) The subsequent treatment and management of complications do not differ from those which have already been described.

In place of causing the soft lens material to extrude after opening the anterior chamber by counter-pressure, the same result may be accomplished by introducing into the opening a suction curet, roofed in to within 2 mm. of its extremity and furnished with a handle and a piece of India-rubber tubing and mouth-piece, to which the operator applies his lips and gently sucks out the lens matter. The arrangement of the tubing is such that no infection from the mouth can enter the wound. This is the *suction operation.*

Operation by the Method of Optical Iridectomy.—In the several varieties of congenital cataract which are partial, and one of which —namely, zonular cataract—has already been mentioned, in place of the discission or linear extraction, improvement in vision is sometimes attempted by an optical iridectomy. Thus, if the opacity is directly central in the form of a *central lental cataract*, or certain varieties of *pyramidal* or *polar* cataract, the rays of light passing through the pupil are obstructed and an artificial pupil may be made opposite some portion of the clear lens, usually inward, downward and inward, outward, or outward and downward. If the vision of an eye affected with cataract occupying the center of the lens is improved by mydriasis, it is worth while to consider the operation, but this alone is not sufficient indication unless one finds by observation that the increased visual acuity, as noted by test-type examination, is also maintained in the ordinary avocations of life under these circumstances. Generally it is better to resort to an operation which creates complete opacification of the lens, so that its entire removal may be effected. If an optical iridectomy is practised, the technic is the same as that which is described on page 878.

Operations and Treatment of Traumatic Cataract.—Any injury which lacerates the capsule of the lens and permits the entrance of aqueous humor into the crystalline body will be followed by either complete or partial opacification of the crystalline body. If the patient is seen immediately after, for example, a penetrating injury, and the lens is already opaque and swollen, it is often possible to interfere at once, either by enlarging the wound of entrance and expressing through it the opaque lens material, washing out with an irrigating syringe particles which cling to the capsule, or by linear extraction (page 875). Under

other circumstances, and if the eye is not seen immediately after the injury, it may be advisable to treat the eye, until inflammatory phenomena have disappeared, with atropin, 4 grains to the ounce, hot compresses, and dionin in 5 per cent. solution. After the inflammatory symptoms have subsided the lens may be extracted, if it is soft by the linear method, or if not, by a formal extraction, according to the method already described. (See page 866.) Occasionally after a blow upon an eye, which ruptures the capsule of the lens and creates a traumatic cataract, or after a penetrating injury, there may be gradual absorption of the opaque lens without operative interference, the aqueous acting upon the lens fibers in precisely the same manner that it does after the operation of discission.

Operative Treatment of Spontaneous and Traumatic Dislocation of the Lens.—In addition to congenital dislocations of the lens, which ordinarily are incomplete, and which consist in a decentration of the lens, are those which occur spontaneously,—for example, in high myopia and choroiditis,—and those which are caused by injury. Under the last named circumstances the lens may be luxated forward into the anterior chamber, or beneath the conjunctiva, or even under Tenon's capsule. If it lodges in either of the last named situations, it appears as a greenish swelling, and may be readily removed simply by incising the overlying tissue. If it is luxated into the anterior chamber, it is readily seen as a yellowish-white body lying in front of the pupil, and should be removed by an incision similar to that practised for ordinary cataract extraction and made with a delicate knife at the corneoscleral margin. If the injury has been sufficiently severe to dislocate the lens into the vitreous humor, its removal is much more difficult. Sometimes this can be accomplished by opening the anterior chamber, exactly as if an ordinary cataract extraction was about to be performed, and introducing through the opening a scoop, or loupe, which is dipped behind the luxated lens into the vitreous humor, and by means of which the body is drawn forward. Under these circumstances a certain amount of vitreous humor is sure to be lost. Occasionally it cannot be reached with the loupe, but may be expelled, as Knapp suggests, by methodic external pressure on the lower part of the eye, which causes it to engage in an upper corneal incision, previously made, where it is lifted out by the loupe in the ordinary manner. While a lens dislocated into the vitreous humor may remain there for a long period of time without doing serious injury, it is apt, by knocking against the ciliary region, to create either iritis or secondary glaucoma, and therefore the attempt to extract it, although a dangerous and difficult procedure, is usually one that is justified.

Should a crystalline lens contain a foreign body, even though it be not luxated, it is best to attempt its extraction by one of the procedures which removes the lens within its capsule. If, however, the foreign body is of metal, it may be dislodged with an electro-magnet and the opaque lens afterward removed by a formal extraction, or by the linear method.

OPERATIONS ON THE IRIS.

Iridectomy.—With the exception of certain operative procedures usually classed under the names *iridotomy*, *iritoectomy*, and *iridocapsulotomy*, and to which brief reference has already been made (page 874), the chief operations on the iris are the various forms of iridectomy.*

The chief indications for iridectomy are: for the improving vision (optical iridectomy); for the relief of increased intraocular tension, especially in glaucoma (anti-glaucomatous iridectomy); for the relief of recurring inflammations of the iris, and to improve the nutrition of the eye after certain inflammations of the uveal tract (antiphlogistic iridectomy);† for the removal of foreign bodies or small growths embedded in the iris; to prepare an eye for the subsequent extraction of cataract (preliminary iridectomy).

Fig. 461.—Introduction of Keratome in Operation of Iridectomy (after Haab).

Operative Technic.—The following instruments are required: A stop speculum, fixation forceps, iris forceps, bent keratome, Graefe knife, blunt hook, iris scissors, probe-pointed scissors, metal spatula, and probe. (For instruments see Fig. 456.) The usual preparation having been made, the eye may be cocainized, or, if the surgeon prefers, placed under the influence of holocain, except in certain cases of high-grade congestion, such as one encounters in acute glaucoma, where, in my opinion, a general anesthetic is required. The speculum is inserted and the conjunctiva and subconjunctival tissue firmly seized with fixation forceps at a point opposite to that of the proposed section, if a lance-shaped knife is to be employed, or upon the inner side of the eyeball, just below its horizontal level, if a narrow Graefe knife is used. Using a keratome, its point is next brought in contact with the apparent corneo-

* Such operations as corelysis, or synechotomy and iridodesis, have deservedly fallen into disuse and are not described; neither is it possible to include numerous modifications of operative technic applied to iridectomies for special purposes. The methods described are those suited to the majority of cases, or those most often encountered.

† This is a term employed by Herman Knapp.

scleral margin, or a millimeter from the junction of the sclera with the cornea, in a direction at right angles to the cornea. This direction it keeps while the point is thrust through the tissue until it just appears within the anterior chamber. The handle of the instrument must now be depressed, so that the point of the keratome shall not wound the iris or the lens, but move in a plane parallel with the iris, which it keeps as the blade of the instrument is slowly pushed onward to the desired depth (Fig. 461). The withdrawal of the knife must be slow and its point kept well toward the posterior surface of the cornea, permitting the aqueous to escape slowly and avoiding the capsule of the crystalline lens.

If a Graefe cataract knife is employed, the method of its introduction is exactly that which has been described in the operation for cataract (page 866). This instrument is preferable and usually necessary if the anterior chamber is shallow. The flap need not be more than 2 mm. in height. After the incision with either of the instruments is completed, the curved iris forceps are introduced with expanded blades in order to grasp the pupillary margin of the iris. The forceps are now withdrawn with the included tissue, which is cut off with one or two snips of the iris scissors, which reach the tissue from the side in the manner shown in the illustration, or, as preferred by many surgeons, from in front over the surface of the cornea (Fig. 462). With a metal probe and spatula the wound is dressed so that no particle of iris tissue shall remain within its lips. The procedure is exactly that which is suited to the second stage of the operation for cataract (page 868). If much blood has followed the cutting of the iris and filled the anterior chamber, it can usually be evacuated by gentle pressure at the base of the cornea, a procedure, however, which must not be tried except in the gentlest manner and for the shortest time possible, in those cases in which the crystalline lens is clear, and is to remain so, lest the trituration should induce the formation of a cataract.

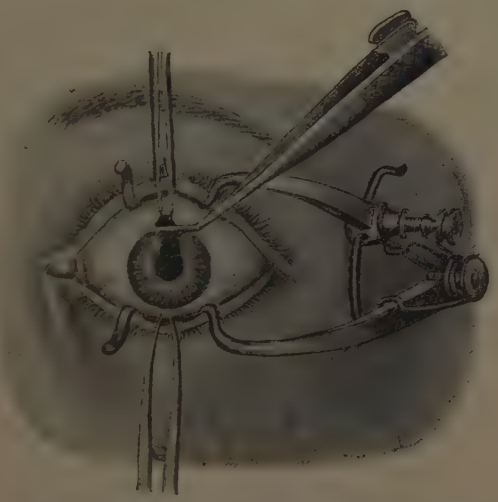


FIG. 462.—REMOVAL OF IRIS IN OPERATION OF IRIDECTOMY.

After most iridectomies, those for glaucoma usually being excepted, a drop of a sterile atropin solution should be instilled before the bandage is applied. The subsequent management of the case, and the complications which may arise during the healing process, as well as their treat-

ment, are largely the same as those already described in connection with the operation for cataract (page 870).

Modifications of Technic Necessary to Meet Special Indications.—*In optical iridectomy* a narrow coloboma, if possible, should be placed inward, or downward and inward, for example, in central leucoma of the cornea, or in central congenital cataract (page 875), and instead of using the iris forceps to withdraw the tissue, a blunt or Tyrrell hook may be employed. Many modifications of optical iridectomy have been tried, the best of them being that known as *precorneal iridotomy*, described by Axenfeld, in which the iris is made to prolapse through a small corneal incision, when it is incised with a radial scissor-cut, not excised, and

FIG. 463.—DRESSING THE PILLARS OF THE COLOBOMA AFTER IRIDECTOMY (after Haab).

carefully replaced. There is gradual separation of the cut, making a narrow aperture in the iris.

In *anti-glaucomatous iridectomy* the anterior chamber must be opened by as peripheral an incision as is safe, and it should be at least 2 mm. posterior to the apparent corneoscleral junction; otherwise the root of the iris cannot be seized. In acute congestive glaucoma it is usually taught that at least one-fifth of the iris should be included in the excised tissue, and it is preferable that the coloboma be made upward. A less extensive iridectomy, if technically correct, will accomplish equally good purposes, and this is especially true if it is performed for non-congestive or so-called chronic glaucoma.

The essential symptoms of that disease, which requires a peripheral

iridectomy for its cure, namely, *acute glaucoma*, are greatly increased intraocular tension, semi-dilated, immobile pupil, shallow anterior chamber, steamy and anesthetic cornea, great reduction of visual acuity, and violent pain.

In *chronic non-congestive glaucoma* there are only slight increase of intraocular tension, not constantly present, no external inflammatory signs, progressive loss of the visual field, especially from the nasal side, marked loss of light-sense, and the ophthalmoscopic signs of the disease, namely, cupping of the optic disc and the formation of a halo about its margin. It may be treated by an iridectomy, also peripheral, but not necessarily so broad as in the acute varieties of the affection.

In both of these diseases myotics are of signal service. In the acute forms either salicylate of eserin or hydrochlorate of pilocarpin should be employed in a strength of 1 to 2 grains to the ounce of the former, and 2 to 4 grains to the ounce of the latter drug, the instillations being repeated with sufficient frequency to contract the pupil. If they fail, iridectomy is necessary. In chronic glaucoma the strength of the myotic solutions should not at first exceed from $\frac{1}{4}$ to $\frac{1}{2}$ grain to the ounce. Iridectomy is much less certain in its effects than in acute glaucoma and is not advised at all by some surgeons. In recent times this disease has been treated by *excision of the superior cervical sympathetic ganglion*. (See Vol. II, p. 745.) The results of this operation, however, have not been satisfactory, and it has been abandoned by many surgeons. Sclerotomy is preferred by some surgeons to iridectomy, or a sclerotomy followed later by iridectomy, as was advised by De Wecker. Some operators endeavor to make a filtering cicatrix in their operations for the relief of glaucoma (Lagrange, Holth, Herbert).

OPERATIONS ON THE SCLERA, CORNEA, AND CONJUNCTIVA.

Anterior Sclerotomy.—This operation is sometimes employed as a substitute for iridectomy. It is also useful to reduce intraocular tension if an iridectomy has failed, and is one of the operations which may be practised for the relief of *hydrophthalmos* or *congenital glaucoma*. It is not as efficient as iridectomy in securing filtration at the angle of the anterior chamber, but has the advantage that it may be repeated as often as necessary.

With a narrow Graefe cataract knife, or a specially constructed knife, a puncture is made through the sclerotic 1 mm. from the border of the cornea and brought out at a corresponding point upon the opposite side, very much in the same manner as the knife is passed across the anterior chamber in the operation of the extraction of cataract, except that the puncture and counter-puncture lie within the sclera, and should be so placed as if it was intended to form a flap 2 mm. in height out of the upper, or equally well out of the lower, part of the cornea. The two punctures are enlarged by means of a slight sawing movement of the knife, which must be withdrawn, however, before the section is completed, leaving the central quarter of the sclerotic flap and as much of the conjunctiva as

possible, except where it is punctured, undivided (Fig. 464). Should prolapse of the iris occur after withdrawal of the knife, it must be excised, as in the operation of iridectomy, if it cannot be replaced with a spatula. To prevent such prolapse, the iris should be under the influence of a myotic before the operation, and this drug should be continued during the after-treatment, which is the same as that suited to an iridectomy. Some surgeons, following the advice of the late De Wecker, are accustomed to perform an anterior sclerotomy in the treatment of glaucoma some days prior to an iridectomy, because they believe that the technic of the latter operation is facilitated by the deepening of the anterior chamber which the sclerotomy causes. Lagrange performs an operation which is practically a combination of sclerotomy and iridectomy for the same purpose. Heine has designed an operation for the relief of glau-

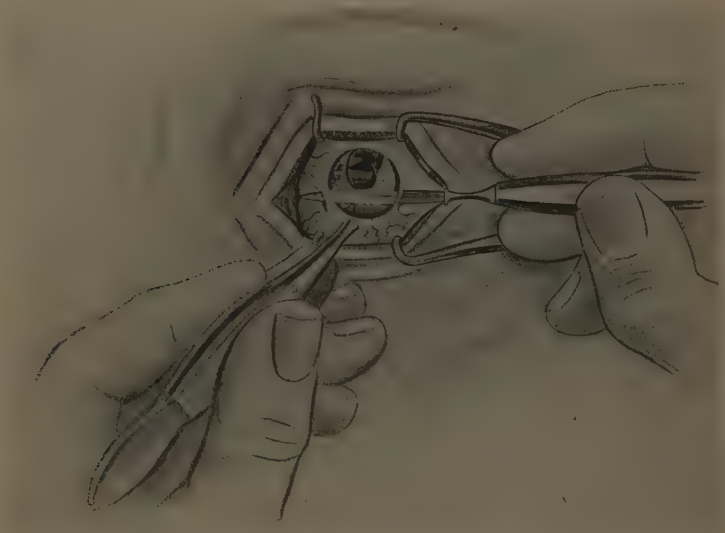


Fig. 464.—Anterior Sclerotomy—Incision Below (after Haab).

coma to which he gives the name *cyclodialysis*. In this procedure an opening is made into the sclera, parallel to the cornea and 6 mm. from it, through which a spatula is introduced between the sclera and the uveal tract through the ligamentum pectinatum into the anterior chamber.

Posterior Sclerotomy.—This operation is employed in hemorrhagic glaucoma which is not suited to iridectomy, and for the relief of detachment of the retina. A Graefe cataract knife is entered at a point between the external and inferior rectus muscles, 8 mm. from the corneal margin, and the blade passed toward the center of the eyeball to a depth of 4 to 6 mm., thus dividing the sclera, the underlying coats of the eye, and the vitreous. Next, the knife is slowly withdrawn in such a manner that it executes a quarter turn, as the result of which a small triangular wound is formed which favors filtration. Like anterior sclerot-

omy, this operation may be repeated as occasion requires, and forms, as Priestley Smith and Harold Gifford, and more recently, Arnold Knapp, have maintained, and as I can confirm from personal experience, a valuable measure preceding an iridectomy for the types of glaucoma just described.

Removal of Foreign Bodies from the Cornea.—Small foreign bodies—for example, cinders, emery, fragments of metal, small thorns, and the like—readily lodge upon the surface of the cornea, or become embedded within its tissues. These accidents are of frequent occurrence; for example, among 8778 patients applying in my service in the University Hospital during four years, 311, or about $3\frac{1}{2}$ per cent. of them, came for the relief of foreign bodies embedded in the cornea. Search for these intruders should always be made with the aid of oblique illumination and a magnifying glass, either of the ordinary type, or, better still, in the form of a corneal loupe, that is to say, a glass specially prepared for inspecting the cornea. If the body is simply lodged upon the surface of the cornea, after this structure is cocainized or holocainized in the usual manner, the body may be flicked from its place with the aid of a probe upon which has been twisted a small particle of sterile cotton. If it is embedded, it must be picked from its position with a sterilized metal spud with as little laceration of the surrounding corneal epithelium as is possible. Afterward the eye should be carefully flushed with a saturated boric acid solution, or a 1: 5000 solution of cyanid of mercury, and if there has been much abrasion of the corneal epithelium, a light compress bandage should be applied for the next twenty-four hours until this epithelium is regenerated, lest the cornea become infected from the conjunctival juices and produce by the entrance of micro-organisms, notably the pneumococcus, a sloughing ulcer. The pernicious habit of workmen of removing foreign bodies from eyes with toothpicks cannot be too strongly condemned and has been the means of producing many cases of hypopyon keratitis. If the foreign body is not found by inspecting the cornea, the lids should be carefully everted and thoroughly examined with the magnifying glass, and often the body will be found either directly underneath the lid, or hidden in the folds of the conjunctiva, from which it may be readily removed in the ordinary manner.

Occasionally small particles of metal, iron or steel, are so deeply embedded that it is difficult to reach them without undue laceration with a spud. Under these circumstances the point of an electromagnet may be applied. If the foreign body passes entirely through the cornea into the anterior chamber, this cavity must be opened in the same manner as if an iridectomy were to be performed and an effort made to seize the body with forceps. If it is entangled in the iris, it may be necessary to remove a small portion of this tissue with the foreign body. If the body is metal it should be removed with a small magnet.

Paracentesis of the Cornea.—This operation may be employed for temporarily reducing the intraocular tension in iritis or uveitis, in corneal ulcers which threaten to perforate, in glaucoma, provided it is not possible to make an iridectomy or sclerotomy, and to drain the anterior

chamber if it contains a collection of pus, blood, etc. It is performed as follows: Either with a narrow keratome or with a paracentesis needle, constructed with a shoulder in order to prevent undue depth of entrance, the cornea is punctured near its lower margin, the instrument being inserted at an angle of 45 degrees with the point of contact. As the needle is withdrawn it should be slightly rotated, so that the lips of the wound are opened and thus facilitate the escape of the contents of the aqueous chamber.

Operative Treatment of Corneal Ulcers.—The forms of corneal ulcer which furnish the indications for surgical interference are chiefly those known as *infected or sloughing ulcers*, in which the lesion in the cornea tends to spread and increase, and is surrounded by a purulent infiltration and often associated with a collection of purulent material in the bottom of the anterior chamber (hypopyon). Usually such an ulcer follows a slight injury of the cornea which becomes infected from the surrounding conjunctival juices, or from the adjacent lachrymal canal, and in 95 per cent. of the cases the active micro-organism is the pneumococcus. Sloughing ulcers, however, also are caused by staphylococci, streptococci, bacterium coli, bacillus pyocyaneus, and by other rarer micro-organisms. Keratitis, due to an infection from the aspergillus fumigatus, is an uncommon disease.

Sloughing keratitis, as it accompanies a number of the infectious diseases,—notably, smallpox, measles, and scarlet fever,—is also encountered, and more rarely certain special types of corneal infection; for example, the infected marginal ulcer, Mooren's rodent ulcer, dendriform ulcers, etc.

Treatment.—The treatment should include a rigorous cleansing of the conjunctival sac with boric acid solution, or bichlorid of mercury, 1: 10,000, or cyanid of mercury, 1 : 5000, and the instillation of an atropin solution, 4 grains to the ounce, with sufficient frequency to maintain mydriasis and prevent iritis. The spread of infection is best checked by coloring the ulcer with a 2 per cent. solution of fluorescin, which stains all the necrotic tissue a yellowish-green color, and touching this area with a probe which has been dipped in a solution of pure carbolic acid, of nitric acid as recommended by Haab, or of trichloracetic acid as advocated by Clifford, L. W. Fox, Bulson, myself, and many others. After the application, or even independently of it, iodoform may be dusted upon the surface of the ulcer and the eye closed with a lightly applied compressing bandage, which is to be renewed at each dressing, two or three times a day. If these measures fail, or if from the beginning the process is sufficiently malignant to demand it, the actual cautery may be applied, either a small Paquelin cautery or a galvanocautery. The edge and floor of the ulcer should be gently but thoroughly burned. If neither a Paquelin nor a galvano-cautery is at hand, an ordinary knitting-needle or a platinum probe heated in a spirit-lamp will suffice. If the intraocular tension should rise, or if there is a large collection of pus in the anterior chamber, paracentesis of the cornea (page 883) may be practised, or an incision made directly through the

ulcer, after the manner of Saemisch, as follows: The lids being separated and the eyeball steadied in the usual manner, a narrow cataract knife is entered on one side of the cornea, and carried across the anterior chamber beneath the ulcer, and the section made forward directly through the diseased area. Through this incision the hypopyon escapes, or if not, it may be removed by means of delicate forceps, or washed out with physiologic salt solution. The after-treatment is exactly that which has been described, and the incision may be reopened with a probe as often as additional drainage is required.

Patients with severe corneal ulcers should be kept in bed, and should have general supporting and tonic treatment. Dionin in 5 per cent. solution locally is of great service and may be used in addition to the atropin. In some cases subconjunctival injections, either of physiologic salt solution or of cyanid of mercury, as recommended by Darier, are of signal service. The *serum treatment* developed by Römer has not met with the success which was at first anticipated. Should the lachrymal sac be inflamed and pus be issuing from the punctum, this must be treated in the usual manner, or, better still, the sac should be extirpated (page 923). Argyrol in 25 per cent. solution and protargol in 20 per cent. solution frequently instilled into the conjunctival sac are of service in the treatment of infected corneal ulcers, and may be applied at each dressing.

Treatment of Corneal, Conjunctival, and Corneoscleral Wounds.—The treatment of an incised or lacerated conjunctival wound, provided this tissue is alone involved, is a comparatively simple matter. After the usual cleansing of the conjunctival surfaces with a boric acid solution, the lacerated tissues may be united with a fine silk suture and a compress bandage applied. The suture should be removed at the end of forty-eight hours. Incised wounds of the cornea are more serious, as under the best of circumstances they interfere with vision. If not of great extent and unassociated with prolapse of the underlying tissues, the conjunctival sac should be sterilized and a compress bandage applied, through which cold applications may be made. Usually union, if infection is prevented, will occur within the first twelve hours. If the wound is an extensive one, and if the iris has prolapsed into it, and if examination has excluded the presence within the eyeball of a foreign body, the prolapsed iris must be replaced, or if this is not possible, abscised, as in the operation of iridectomy, and the eye treated, after bandaging, precisely as after an iridectomy.

In extensive wounds of the cornea it has been suggested by De Wecker, Kuhnt, Gamo Pinto, and other surgeons that healing may be secured more rapidly, and infection prevented, if the wound is temporarily covered with a flap of conjunctiva, obtained by loosening this membrane from the neighboring eyeball and holding it in place over the wounded cornea by means of sutures. As soon as the corneal wound has healed, the conjunctival covering is returned to its original situation. In place of using a conjunctival flap for this purpose gelatin wafers impregnated with iodoform, as recommended by Mules, or with collargol, as suggested by

Maitland Ramsay, may be employed. They are placed over the wound and held in place by means of a bandage until union takes place.

Of even greater surgical importance are wounds situated at the corneo-scleral junction, because of their proximity to the so-called dangerous region of the eye (page 854), which, indeed, is frequently involved. They are usually inflicted by some sharp instrument, for example, a piece of glass, or wire, or knife-blade, or tine of a fork, etc. Associated with the wound almost always there is prolapse of the underlying tissue, either of the iris, or, if the wound has extended into the sclera, of the ciliary body.

The treatment differs according to the conditions found at examination.

1. If the wound is fresh, and there is no prolapse of underlying tissue, and examination has determined the absence of a foreign body within the eye, the measures already described in connection with corneal wounds are applicable.

2. If the wound is fresh, and there is prolapse of underlying tissue, and there is no foreign body within the eye, the prolapsed material should be carefully removed, exactly as if an iridectomy were being performed, and with the same instruments. The edge of the wound should next be penciled with a solution of bichlorid of mercury, 1 : 2000, and if it is gaping, drawn together with a delicate silk suture, which should be passed through the divided conjunctiva and not through the underlying sclera. The subsequent treatment of compressing bandage, atropin mydriasis, rest in bed, and the internal administration of some form of mercury, preferably calomel, should be carefully carried out.

3. If the wound is seen late and infection has already begun in the form of a purulent iritis, or a purulent infection of deeper tissues, or if the eye contains a foreign body which cannot be removed, or if the patient cannot be under constant expert observation, or if the eye shows increasing and intractable inflammation, it should be enucleated, to prevent sympathetic ophthalmitis.

If conservative measures are attempted, the strictest cleansing of the involved tissues should be practised. If the recommendation of Haab is followed, a small rod of sterilized iodoform may be introduced through the wound into the anterior chamber. This practice, however, has not met with the approval of all surgeons, and in my experience is not a necessary nor always a wise procedure.

Wounds of the sclera may be made by any sharp instrument, or by a foreign body, or may be caused by a blow, and constitute the so-called *ruptures of the sclera*, most frequently found about 3 mm. from the corneo-scleral junction and concentric with it (compare page 853). They may be *simple ruptures*, that is to say, the overlying conjunctiva is not divided, or *compound ruptures*, that is to say, the overlying conjunctiva is divided. Exactly the same principles of treatment which have just been recited are applicable. Usually the stitches which close a wound through the sclera should not pass through the scleral tissue itself, but only through the overlying conjunctiva. Where the scleral wound is a large one and

gaping is wide, an additional single scleral suture is recommended by some surgeons.

The consequences of any of these wounds may be serious, the most noteworthy complications being *sympathetic ophthalmitis*, traumatic cataract, infection of the uveal tract and panophthalmitis, and even after complete healing, late detachment of the retina.

The constitutional treatment of these injuries must never be lost sight of, and the best results are secured by the administration of mercury, as already mentioned, in the form of calomel, or, as Schirmer prefers, by means of inunctions. Of excellent repute also is the exhibition of full doses of salicylate of sodium after the course of mercury, this remedy seemingly having the power of preventing the development of so-called sympathetic disease, or even, as Dalén has shown, of lessening the severity of the manifestation should it arise.

Sympathetic ophthalmitis, due in at least 80 per cent. of the cases to traumatism of the ciliary region, and liable to occur in about 13 per cent. of injured eyes (Fuchs), usually does not arise until three to six weeks after the injury of the "*exciting eye*," and manifests itself in general in some form of iridocyclitis, with extensive involvement of the uveal tract in the "*sympathizing eye*." The pathogenesis has not been definitely settled, although we know that the old theory of a transference of impulses or poisons by way of the ciliary nerves is no longer tenable. It is doubtful, too, if Deutschmann's theory of migratory ophthalmitis should be retained. Römer's beautiful researches indicate, as Berlin originally thought, that the disease should be regarded as a *metastasis*, the metastatic infection proceeding by way of the blood-streams and depending upon some form of micro-organism pathogenic for the eye and not affecting the body generally. Some investigations of Zur Nedden indicate the discovery of this organism, but they are not confirmed, and he himself is uncertain. Fuchs's remarkable investigations of the anatomy of sympathetic ophthalmitis indicate that the lesions are characteristic (this is denied by Ruge and others) and develop in a definite form of infiltrating or proliferating uveitis. He believes that the pathogenic agent enters the second eye through the circulation, and that the whole process should be regarded as a metastasis, exactly as this occurs in tumors. Therefore Berlin's theory and Römer's researches appear to be receiving anatomic confirmation. The *treatment* of sympathetic ophthalmitis, if it exists, is that suited to iritis—atropin, dionin, subconjunctival injections, mercury, and large doses of salicylate of sodium. It should be prevented by the enucleation of the "exciting eye "where the indications already recorded are present.

Treatment of Burns of the Cornea and Conjunctiva.—Injuries of this character are commonly inflicted with lime (mortar or quick-lime), molten metals, powder, acids, and strong alkalis. The prognosis is particularly grave in carbolic acid, lime, and ammonia burns, and often under the best of circumstances sloughing of the cornea, iritis, and panophthalmitis arise. Even when these serious sequels are averted, the destruction of the mucous covering of the inner surfaces of the lids and the

eyeball is apt to be followed by an adhesion of these tissues, or the formation of a symblepharon.

After an accident involving a burn of the regions named, all foreign substances should be removed as quickly as possible. In lime burns, if any offending particles remain, they may be flushed out with water, or preferably, as Schmidt-Rimpler points out, with oil introduced with a syringe. Subsequently the pupils should be dilated with atropin, the cul-de-sac of the conjunctiva kept scrupulously clean and lubricated with olive or castor oil. In order to prevent adhesion between the lids and the eyeballs, it has been suggested to place between them a piece of gold-beater's skin, or of thin rubber protective, or the skin which lines the inner surface of an eggshell. In my experience none of these expedients

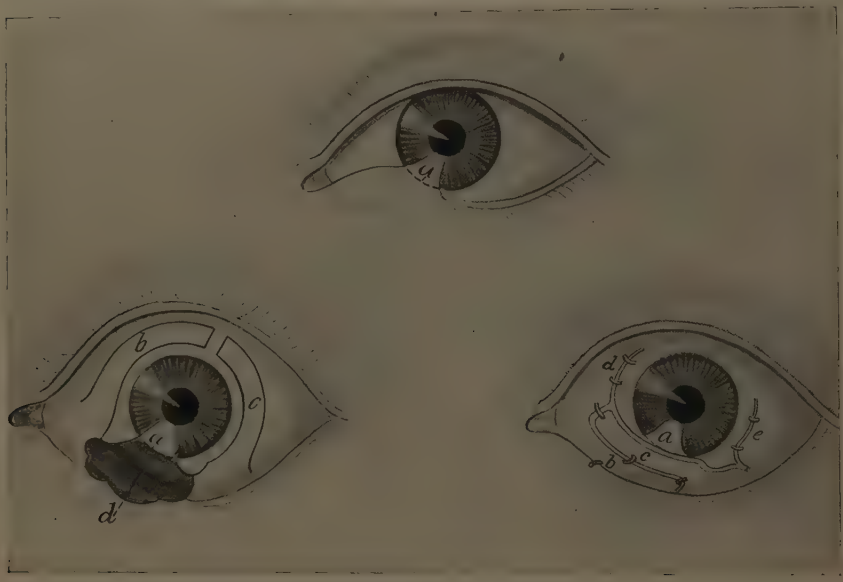


FIG. 465.—TEALE'S OPERATION FOR SYMBLEPHARON.

The symblepharon is detached at *a* and removed. Two conjunctival flaps, *b* and *c*, are formed and turned to cover the denuded surface of the eyeball and of the inner side of the lid. The conjunctival gaps are closed by sutures, *d* and *e*.

are as valuable as the systematic breaking up of adhesions several times a day with a probe, associated with rigorous local antisepsis.

Operations for Symblepharon.—If in spite of these precautions a symblepharon forms, after all inflammatory symptoms have subsided, an attempt must be made to remedy the condition. Unfortunately, the results are often most unsatisfactory. In general terms, the adhesions should be divided, and the raw surfaces left after they are severed covered with flaps of healthy conjunctiva taken from the unaffected parts of the eyeball. This is Teale's method (Fig. 465). Occasionally the symblepharon can be dissected back to the retrotarsal fold and doubled upon itself, so as to oppose a mucous surface to the globe. It is fixed in position by means of a ligature armed at either end with a needle passed

through the lid from the conjunctival surface. In more extensive symblepharons an attempt may be made, after the eyelid has been dissected from the eyeball, to prevent readhesion by inserting a graft made of rabbit's conjunctiva, or, as Hotz suggests, a Thiersch graft. As the movement of the lid is apt to displace it the transplanted skin, following the advice of Hotz and May, may be secured by means of a rigid support, for example, a thin piece of lead, or a suitable glass prosthesis. This plate may be made of melted lead and covered with paraffin, as recently recommended by Wilder.

Operations for Pterygium.—To remove a pterygium, which is a triangular shaped growth composed of vascular hypertrophied conjunctival and subconjunctival tissue, in its true form usually situated at the inner side of the eye with its apex attached to the corneal border, a variety of operations have been practised, which in general terms include excision, strangulation by ligature, and transplantation. Excision is suited to a small pterygium, as the bared surface left after its removal may be covered by stitching together the margins of the conjunctiva. Usually, however, some form of transplantation is required, preceded by splitting the growth, after its apex has been detached, as in Knapp's operation, or transplanting it in its entirety, as in the operation of Desmarres, which has been modified by John D. McReynolds, and which is an excellent procedure. The description which follows is in McReynolds' own words:

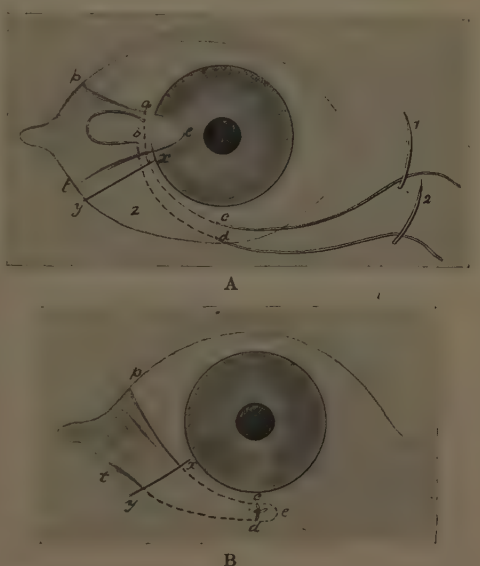


FIG. 466.—McREYNOLDS' OPERATION FOR PTERYGIUM.

A, Showing needles 1 and 2, which enter the neck of the pterygium *p t e* at *a* and *b*, and then pass beneath the loosened lower segment of conjunctiva *x y z*, and then emerge at *c* and *d* below the cornea. B, showing pterygium *p t e* fixed by a single stitch *c d* beneath the loosened lower segment of conjunctiva *x y z*, while the former site of the growth *p x t* is covered by the normal smooth, stretched and thinned out conjunctiva *p x t*.

"Grasp completely the neck of the pterygium with strong but narrow fixation forceps. Pass a Graefe knife through the constriction and as close to the globe as possible, and then, with the cutting-edge turned toward the cornea, smoothly shave off every particle of the growth from the cornea. With the fixation forceps still hold the pterygium, and with slender straight scissors divide the conjunctiva and subconjunctival tissue along the lower margin of the pterygium, commencing at its neck and extending toward the canthus, a distance of ¼ to ½ of an inch. Still hold the pterygium with the forceps, and separate the body of the growth

from the sclera with any small, non-cutting instrument. Now separate well from the sclera the conjunctiva lying below the oblique incision made with scissors. Take a black silk thread, armed at each end with small curved needles, and carry both of these needles through the apex of the pterygium from without inward and separated from each other by a sufficient amount of the growth to secure a firm hold. Then carry these cutting needles downward beneath the loosened conjunctiva lying below the oblique incision made by the scissors. The needles, after passing in parallel directions beneath the loosened lower segment of the conjunctiva until they reach the region of the lower fornix, should emerge from beneath the conjunctiva at a distance of about $\frac{1}{8}$ to $\frac{1}{4}$ of an inch from each other. Next, with the forceps, lift up the loosened lower segment of the conjunctiva and gently exert traction upon the free ends of the threads, which have emerged from below, and the pterygium will glide beneath the loosened lower segment of the conjunctiva, and the threads may now be tightened and tied and the surplus portion of the thread cut off, leaving enough to facilitate the removal of the threads after proper union has occurred. It is extremely important that no incision be made along the upper border of the pterygium; otherwise it would gape and would leave a denuded space when downward traction is made upon the pterygium" (Fig. 466).

With the operation of strangulation by ligature, destruction of the apex with cautery, and similar procedures I have had but slight experience, and they do not appeal to me. Occasionally a large, fleshy, and especially so-called *pseudo-pterygium* must be treated as is a symblepharon (see page 888).

Operations for Staphyloma.—One of the results of the distention of a cicatrix formed after the healing of a corneal ulcer to which the iris is adherent is a staphyloma, which may be partial, or if the entire cornea is involved, total. Occasionally sufficient clear cornea remains to improve the vision somewhat by an optical iridectomy (page 880), or, if this is not feasible, a partial staphyloma may be amputated and the wound allowed to heal under a compressing bandage, or the lips approximated by means of sutures which pass only through the conjunctiva. It was the practice at one time to amputate total staphylomas, and after permitting the lens to escape to draw the edges together with interrupted sutures, which passed through the sclera, as in Critchett's operation, or to cover over the amputated surface with sutures inserted in the conjunctiva, which was first carefully dissected from the corneal margin almost as far as the equator of the eyeball, as in De Wecker's method, or passing them through the episclera or sclera, as Knapp suggested, but never through any part of the uvea. Under the name *combined keratectomy* this operation was practised by Panas, the cornea being amputated and the iris and lens carefully removed and the wound closed with sutures. Should there be ciliary irritation, iridocyclitis, or sympathetic irritation, these operations are contraindicated, although if successful they furnish an excellent stump on which to rest prosthesis. Late irritability of the stump, however, rendering its removal necessary, is some-

times noted, and undue reaction, sympathetic irritation, and even sympathetic ophthalmitis have occurred, and generally the operation is less desirable than enucleation or one of its substitutes, an exception being in non-inflamed, staphylomatous eyes, as they occur in children.

Numerous operations have been devised for the relief of **conical cornea,** and these are sometimes necessary, provided the visual acuity cannot be raised with suitable lenses to the required degree. Of all of those devised, a careful touching of the cone with a button-shaped electrocautery and thus producing a contracting scar, furnishes the best results.

Operations for Granular Lids.—Granular conjunctivitis, or that disease in which there is an inflammatory infiltration of the adenoid layer of the conjunctiva, associated with a development of follicles or trachoma granules and enlargement of the papillary layer, is often best managed by operative procedures. Numerous methods have been devised. Among these the most important are: Abscission of the granulations, excision of the retrotarsal folds, or of a strip of the infiltrated fornix, removal of a part of the tarsal conjunctiva at the same time that the strip of infiltrated fornix is excised, the so-called combined excision, extirpation of the tarsus (Kuhnt's operation), and squeezing or rolling out of the trachoma follicles with suitable instruments, especially such as have been devised by Noyes, Knapp, and Kuhnt.

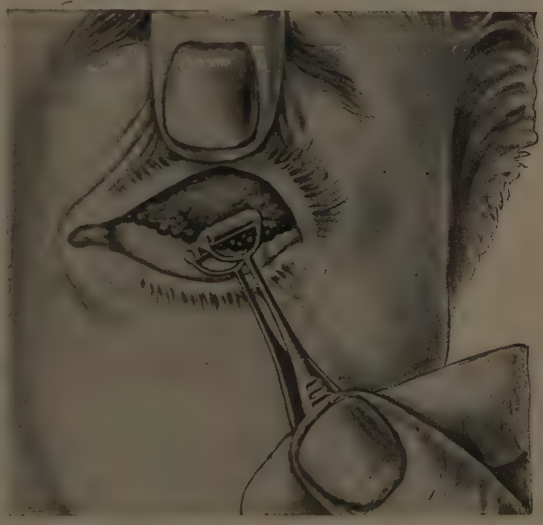


FIG. 467.—KNAPP'S OPERATION FOR TRACHOMA (Hansell and Sweet).

Of these various procedures, the **operation of expression,** often known as Knapp's operation, is usually the most satisfactory. With the aid of either general or local anesthesia, the upper lid is everted and the palpebral conjunctiva thoroughly exposed. Next, this is scarified superficially, and one blade of a Knapp's roller forceps (Fig. 467) is pushed deeply between the ocular and palpebral conjunctiva and the other applied to the everted surface of the tarsus. The forceps are now compressed and drawn forward and the infiltrated, soft tissue squeezed out as the cylinders roll over the surface of the fold held between them. This maneuver should be repeated until all of the morbid material has been thoroughly removed. The lower retrotarsal fold is treated in precisely the same way, and during the operation the exposed surfaces are flooded

with a tepid solution of bichlorid, 1 : 8000. Cold compresses may be placed upon the eyelids for the next twenty-four hours, and subsequently there should be daily exposure of the conjunctival surfaces, which are touched with nitrate of silver, 10 grains to the ounce, or painted with protargol, 20 per cent., or rubbed with a stick of the sulphate of copper, according to circumstances.

Some surgeons prefer the operation of *grattage*, in which after exposure of the infiltrated tarsal conjunctiva and its scarification, bichlorid of mercury, 1 : 2000, is rubbed into the tissues with a brush. The reaction is apt to be very severe, and the operation possesses no advantages over the one just described.

Of the other operations which have been mentioned, excision of a strip of conjunctiva containing the trachoma granules, or of the exposed fornix, the wound afterward being closed with sutures, is the least objectionable. With extirpation of the tarsus as recommended by Kuhnt in certain cases of chronic trachoma and greatly infiltrated tarsus, I have had no experience.

Tattooing the Cornea.—The disfigurement occasioned by the presence of a dense leucoma the result of a corneal ulcer may be lessened by tattooing the center of the tissue with India ink, which has been rubbed up with water into a fine paste, and which is pricked into the scar with an ordinary cataract needle, or with several needles set side by side. An attempt to obtain a uniform black surface should be made, and with care surprisingly good results may be obtained.

Tumors of the cornea, if benign,—for example, dermoids, papillomas, and certain cysts,—especially if situated at the corneoscleral junction, may be removed by an ordinary dissection. **Epibulbar sarcomata,** if limited, have been treated in like manner; but as there is a history of recurrence in fully 80 per cent. of the cases, Verhoeff and Loring properly recommend immediate removal of the eyeball.

TREATMENT OF FOREIGN BODIES LODGED WITHIN THE EYEBALL.

The treatment of foreign bodies within the eyeball differs according to the character of the foreign substance. If the foreign body is composed of iron or steel and its presence and position cannot be determined owing to opacities in the media, or blood which fills the chambers of the eye, a diagnosis is possible with the aid of a magnetic needle, as was originally suggested by T. R. Pooley, of New York. Asmus and Hirschberg have constructed instruments, known as *sideroscopes*, by means of which a properly protected magnetic needle is held near the eye in different positions, and any deviation of the needle carefully noted. Where the deviation is greatest there is reason to suspect the presence of a foreign body. In recent years large, or so-called giant, magnets have been employed for diagnostic purposes. When such a magnet is placed close to the eye, it may dislodge the foreign body, the movement of which causes a localized pain. Sometimes, as will presently be shown, not only is the pain produced, but the body itself is drawn forward into the anterior chamber.

The absence of pain, however, does not exclude the presence of a foreign body, and therefore the test is not a perfectly sure one.

By far the most accurate method of diagnosis under the conditions named consists in the employment of the *x*-rays, a plate-holder being placed upon the side of the head, and after suitable exposures a search is made on the skiagram for the shadow cast by the foreign body. Numerous methods have been devised for the use of the rays under these conditions; three—those designed by McKenzie Davidson, of England, William M. Sweet, of Philadelphia, and George Dixon, of New York—being in my judgment the most efficient, and of these three my experience has been the greatest with Sweet's method of localization. To quote Sweet's words: "These methods of localizing foreign bodies in the eyeball by means of the Röntgen rays are all based upon the study of

FIG. 468.—SHOWING THE USE OF THE LARGE MAGNET IN EXTRACTING AN IRON SPICULE FROM THE EYE (Haab).

the shadow of the foreign substance on the radiograph in its relation to the shadow of one or more known points in relation to the eyeball. These fixed points from which the measurements are made may be situated on the eyelid or cheek, or suspended in front of the eyeball." Space does not permit a description of the technic of localizing bodies in this manner, and the reader is referred to the original papers of those whose methods have been commended.

With the Sweet apparatus, especially in the skilful hands of its designer, as well as those of Howard Pancoast, of the University Hospital, in my experience failure to detect the foreign body has practically never occurred, even if it was very small. Not only is the body detected, but its exact position is localized, so that the operative procedures which presently will be described are undertaken with the greatest facility.

In former times, before the introduction of giant magnets, ordinary

hand magnets of moderate drawing power, notably the Hirschberg magnet, were employed. The extension-point of the instrument was introduced if the body was in the vitreous chamber, or in the posterior portion of the eye, either through the original wound of entrance, or one made at the position where the body was assumed to be lodged. Often a successful and brilliant operation, it had the disadvantage of requiring the introduction within the vitreous chamber of an instrument and the disturbance of the delicate structures within. These small magnets, however,—still commended by some surgeons, notably by Simeon Snell,—are of great value in removing bodies which remain within the anterior chamber, or which have been drawn there by more powerful magnets, the small extension-point being readily introduced through a small opening made in the anterior chamber with a keratome.

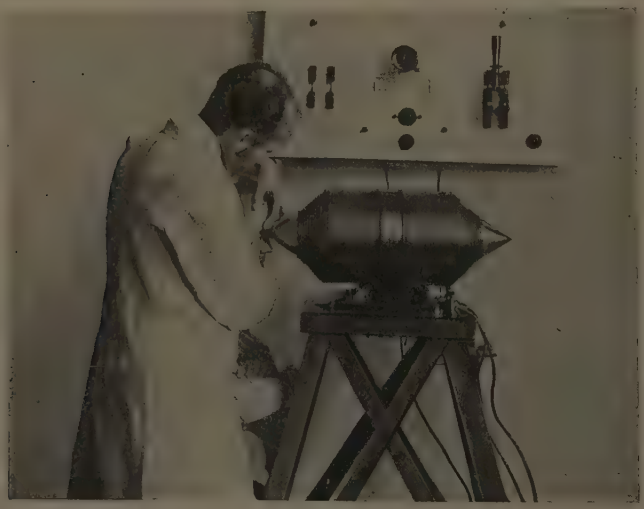


FIG. 469.—SHOWING THE USE OF THE LARGE MAGNET IN EXTRACTING AN IRON SPICULE FROM THE EYE (Haab).

If the body is lodged in the chamber or entangled in the iris, this procedure is satisfactory.

A great advance in the removal of magnetic bodies followed the introduction of the giant magnet by Haab (Haab's operation). This operation may be readily understood by a reference to the accompanying illustrations (Figs. 468, 469) and by following the directions of Haab, as follows: "After the usual antiseptic precautions and thorough cocain anesthesia, the center of the cornea is placed exactly opposite the pole of the magnet. If the presence of a large splinter is suspected, the pole of the magnet should first be allowed to act at some distance from the eye, the patient being told to look in the direction of the pole of the magnet. Occasionally first closure of the current may draw the foreign body behind the iris; if not, the current must be repeatedly opened and closed. If under these conditions there is still no

bulging of the iris, more lateral portions of the cornea are successively brought opposite the pole, care being taken to avoid the region of the ciliary body. Should the body be drawn in such a manner that its presence is indicated by the bulging of the iris, the current must be carefully regulated until the splinter passes through the pupil into the anterior chamber, from which it can readily be removed through a suitable corneal incision, either by introducing the extension-point of a small magnet, or by finishing the operation with a suitable extension-point attached to the giant magnet."

Exact localization with the Röntgen rays is not necessary if a giant magnet is used, as the body is usually drawn by the force of the magnet from whatever position it originally occupied into one from which it may be readily removed, but in my judgment it is far preferable to localize exactly by means of the Röntgen rays the position of the body, and then to make directly over it an incision through which it may be drawn, if preferred by a Haab magnet, or by one less bulky,—for example, the Sweet or Parker model,—without the introduction of the extension point into the vitreous, which simply touches the lips of the opened sclera. The results are just as good as when the attraction of a giant magnet conducts the body from its place in the posterior part of the eye, around the lens into the anterior chamber, from which it is subsequently removed. Indeed, this direct extraction after suitable localization yields better results, because it avoids the traumatism which is produced by the body when it takes a long route into the anterior chamber. To be sure, each case is a separate problem, and must be managed according to the conditions which surround it.

In my experience with magnet operations, I have been enabled to save (this word being used to indicate that neither enucleation nor evisceration was required) 70 per cent. of the eyes which came under my care, while in 30 per cent. the original wound or subsequent inflammation made enucleation necessary. Of the 70 per cent. of saved eyes, 38.4 per cent. secured good vision. Much depends upon how soon after the accident the eye is seen and how little laceration of the tissues is caused by the necessary manipulations. If infection is already present, it can sometimes be checked, as Haab recommends, by the introduction into the wound after the body has been removed of sterilized iodoform rods, or by an actual cauterization of the tract of the wound with a galvanocautery, as Van Millingen recommends. If in spite of this, iridocyclitis persists, the eye should be enucleated to avoid sympathetic inflammation. If the foreign body cannot be dislodged by any suitable operative procedure, enucleation is usually required.

OPERATIONS ON THE OCULAR MUSCLES.

Operations on the ocular muscles are performed for the purpose of correcting derangements of the movements of the eye of such a nature that one eye deviates or tends to deviate from the point of fixation, that is, from the object which it is regarding. If the deviation of the eye is

one which the patient cannot overcome, it is a *manifest deviation* or *strabismus*, or *heterotropia*. If there is only a tendency of the visual line to deviate from the point of fixation, it is a *latent deviation* or *strabismus*, or *heterophoria*. The deviation of a manifest strabismus may be inward (convergent strabismus), outward (divergent strabismus), upward (sursumvergent strabismus), downward (deorsumvergent strabismus), and this strabismus may be *concomitant*, under which circumstances it is characterized by the power of the squinting eye to follow the movements of the other eye in all directions, the angle of the squint always remaining the same, or *paralytic* strabismus, which if complete is characterized by the failure of the affected eye to move in the line of direction of the action of the affected muscle, and is accompanied by diplopia.

(a) **Concomitant convergent strabismus, or esotropia,** which usually begins about the third year of life, and which in general terms depends upon a disturbance of the relation between accommodation and convergence caused by errors of refraction, together with an inequality in the vision of the two eyes and a disturbance of innervation and defective development of the fusion faculty, must always be first treated by an accurate neutralization of the refractive error after thorough mydriasis with atropin. Glasses should be adjusted as soon as possible after the squint is detected, and if there is amblyopia of one eye, its vision should be trained by excluding the sound eye with a shade or bandage, or by keeping it under the influence of atropin for long periods of time. The fusion faculty should be trained by suitable stereoscopic exercises, and of the various instruments at present available the best results are accomplished with the Worth amblyoscope or one of its modifications. If these methods fail to bring about parallelism of the visual axes, even though the fusion power has been developed by the exercises named, operative treatment is desirable, but is not wise before the eighth year of life, and not until the glasses and exercises have been tried for at least six or seven months.

The simplest of these operations is **tenotomy** of the internal rectus, which requires the following instruments: A stop speculum, two strabismus hooks, fixation forceps, and a pair of probe-pointed scissors. In young children general anesthesia may be necessary; in others cocain-adrenalin anesthesia is quite sufficient. The stop speculum is introduced, the surgeon seizes with fixation forceps a fold of conjunctival and subconjunctival tissue parallel with the corneal margin over the insertion of the tendon (see page 851), and divides the tissue raised by the forceps in a horizontal direction down to the sclera, and also opens the capsule of Tenon. Next, the point of a strabismus hook is passed behind the insertion of the tendon, which should be carefully lifted from its position upon the sclera and put slightly upon the stretch, and while in this position cut from its attachment close to the sclera by means of the blunt-pointed scissors. The hook is now passed, with its point turned above and below, and any tendinous fibers which may have escaped are divided (Fig. 470). If the division has been a correct one, the hook will pass readily to the corneal margin. The conjunctival wound is closed by a

single vertical suture, unless it is desired to diminish the effect of the operation, when the suture is passed in a horizontal direction. The conjunctival cul-de-sac should be thoroughly flooded with tepid boric acid solution, and both eyes lightly bandaged for two days, or, if the patient remains in the house and under observation, no bandage is applied, but the correcting glasses are worn immediately after the tenotomy, and the eyes, if necessary, shaded with dark glasses. This is the open method of operating, sometimes called Graefe's method. In place of it, Snellen's modification is very satisfactory. In this a small incision about 4 mm. in width is made through the conjunctiva over the insertion of the tendon, the center of which is then incised vertically. Through the open-

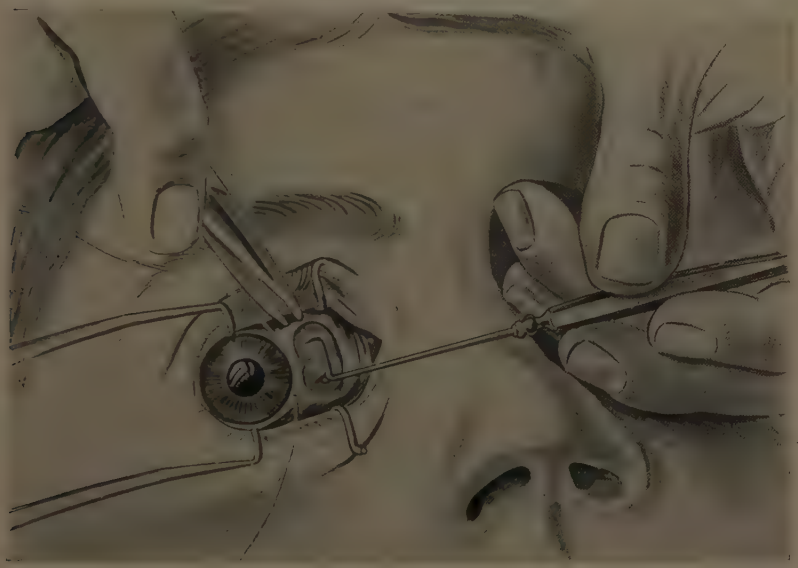


FIG. 470.—EXPOSURE OF THE INTERNAL RECTUS TENDON, WHICH IS LIFTED UPON A HOOK (after Haab).

This drawing also illustrates Prince's method of advancement (page 899). The suture in the sclera, to which the tendon is afterward fastened, is seen lying along the corneal margin.

ing the point of a strabismus hook is inserted, and the upper and lower half of the tendon respectively divided.

In place of these methods, the tendon may be reached, as was advised by Critchett, through a *subconjunctival incision.* With a fine-toothed forceps a fold of conjunctiva and subjacent fascia on a level with the lower border of the tendon is seized, and an opening made just large enough to admit a strabismus hook, which is insinuated behind the tendon, the wound at the same time being held open with the forceps. After its insertion, the hook is pressed firmly against the sclerotic and pushed between this and the tendon as far as the elbow of the instrument will permit. It is next drawn forward and outward toward the cornea and will be stopped by the insertion of the tendon. The scissors, with blades slightly parted, are next introduced into the wound between the hook

and the eye and the tendon divided close to its sclerotic attachment. Subsequently the hook is passed through the opening several times in order to catch any strands which may have escaped.

Complete tenotomy of the internus usually corrects a deviation of 15 to 20 degrees angular measurement. It is not desirable to neutralize the deviation completely, lest divergence occur in later life. In some forms of strabismus each internus may be divided, especially if the strabismus is alternating, with good vision in each eye, but great care is necessary before performing these bilateral operations to avoid subsequent divergence. Generally, if the squint is unilateral and exceeds 30 degrees, and the deviating eye is amblyopic, it is necessary to combine tenotomy with advancement of the antagonistic muscle, or, as is especially advocated by Landolt, to dispense altogether with tenotomies of the internus because of the bad effect which they afterward have upon converging power, and gain the desired result by a bilateral advancement of the externi.

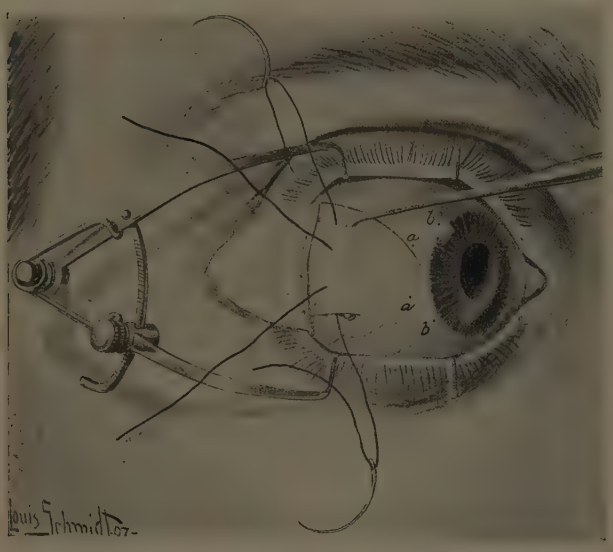


FIG. 471.—LANDOLT'S METHOD OF ADVANCEMENT.

Advancement of a Rectus Tendon.—In convergent strabismus of such character that advancement is required of the external rectus muscle, the operation may be performed as follows, and with the same instruments that are used in tenotomy, to which are added suitable curved needles, a needle-holder, silk thread, and advancement forceps: An opening is made in the conjunctiva immediately over the insertion of the tendon which is to be advanced, twice the breadth of the tendon, and the band of conjunctiva between this opening and the cornea separated from the sclerotic. A strabismus hook is next inserted beneath the tendon, which is freely separated from the sclera, and the hook brought well up to the insertion of the tendon, great care being taken that the whole width of this structure is held on the hook. A curved needle carrying a strong silk suture is introduced from the upper margin of the tendon, between it and the sclerotic, and passed through the tendon at its middle line. In similar manner another suture is passed behind the tendon from

its lower margin and through it close to the first suture. At this stage some surgeons knot the sutures firmly on the tendon, a long end being left to each, although this knotting is not a necessary procedure and somewhat complicates the subsequent removal of the suture. For the strabismus hook a Prince's advancement forceps is now substituted, which grasps the tendon firmly. The needle on the end of each suture is next passed through the episcleral tissue and beneath the conjunctival flap to the margin of the cornea, and, while an assistant rotates the eyeball toward the muscle which is to be advanced, each suture is tied with its own end. Redundant tissue may be trimmed away and the conjunctiva sewed with three interrupted sutures over the advanced tendon.

The subsequent treatment requires a light compress bandage over both eyes, which should be in place for at least seven days, at the expiration of which time the bandage is dispensed with, the sutures removed, and the patient required to wear his correcting glass.

Space does not permit any attempt at a description of the numerous modifications of advancement which have been designed by various surgeons. Among these the most useful are Landolt's method, the technic of which can be understood from the accompanying illustration (Fig. 471); Prince's method of advancement, which depends upon forming an unyielding fixation point by utilizing the dense episcleral tissue, severing the muscle, and regulating the effect by a pulley suture; Schweigger's method of free exposure of the muscle, and after the tendon is divided resection of a portion of its end; Bruns' method, by means of which a tuck in the tendon is formed, which is firmly flattened down, drawn strongly forward, and held in place by a combination of pulley and guy suture; Todd's method, by which a considerable portion of the tendon is exposed by means of a flap incision through the conjunctiva and capsule, and the formation, with the aid of an instrument known as a tendon-folder, of an actual fold, the duplicature being fixed with catgut sutures enforced with silk sutures which include the conjunctival flap; and Worth's method of advancement, by means of which the portion of the suture with which the tendon is concerned is secured by including the adjoining Tenon's capsule with the tendon.

In place of advancement of the tendon, there have been several operations designed, which in general terms may be described as shortening of the tendon, or, instead of advancing the tendon itself, an advancement of the capsule of Tenon has been practised, especially by De Wecker and Knapp. The last named operation, however, is rather temporary in its results. It is, however, suited to relieve small defects, especially various types of heterophoria.

Some idea of the numerous operations which have from time to time been devised may be gained from the statement of Haab, who after describing fourteen of these operations says he has by no means exhausted the subject.

(b) **Divergent Concomitant Strabismus, or Exotropia.**—In this affection there is a divergence of one eye from the point of fixation, and if after correction of the refractive error and exercises suited to train-

ing convergence, the deviation continues, it may be corrected either by a bilateral tenotomy of the externi, performed in precisely the same manner as when the internus is divided, or, more frequently and always more successfully, by an advancement of one or both interni, according to the methods already described in connection with the externus. These same operations are suited to the superior and inferior recti muscles, if the occasion for their division or advancement should arise.

(c) **Paralytic Strabismus.**—Occasionally, in long-standing paralytic strabismus, when this has not yielded to remedial agents directed to the removal of the cause of the strabismus, or to orthoptic training, operation is justifiable, and the methods already described may be put into practice, and generally, provided it is a rectus muscle that is defective, the operation of advancement.

(d) **Latent strabismus, or heterophoria,** in which there is only a tendency of the visual axes to deviate from parallelism, is sometimes treated by means of operation. Should there be an excessive action of one muscle,—for example, a convergence-excess producing esophoria, or a tendency to inward deviation,—tenotomy of an internus may be performed; or a divergence-excess producing exophoria, a tenotomy of the externus. Exophoria, due to convergence-insufficiency, indicates advancement of the internus, and esophoria, dependent upon divergence-insufficiency, advancement of the externus.

In like manner tenotomies of the superior recti are performed when there are tendencies to vertical deviations.

In place of complete tenotomies, partial tenotomies have been especially advocated by Stevens and those who follow his teachings. In these a sufficient number of the fibers of the tendon upon which the operation is performed are divided to produce orthophoria, or parallelism of the visual axes, careful measurements with prisms, or with a Maddox rod, or similar instrument being made during the operation, which is exactly graduated to meet the required results. For the details of performing such operations and for the indications which they meet the reader must consult books especially devoted to ophthalmology. I am strongly of the opinion that operations for the relief of heterophoria should not be performed until all measures, especially those which include the various forms of gymnastic exercises with prisms and suitable correction of the refractive error, have been carefully and prolongedly tried, and that so-called "graduated tenotomies" are usually unsatisfactory procedures.

ENUCLEATION OF THE EYEBALL AND ITS INDICATIONS.

The indications for removal of the eyeball are the following:

1. Malignant growths situated in the retina (glioma), the choroid and ciliary body (sarcoma), the surface of the eyeball (epibulbar). Exceptionally epibulbar growths can be removed without sacrificing the entire globe.

2. Certain types of orbital growth, so situated that they cannot be reached by any other method.

3. Staphyloma and buphthalmos, if these are unsightly, or painful, owing to recurring inflammation.

4. Eyes blind from iridochoroiditis, glaucoma, phthisis bulbi, especially when associated with pain, inflammation, etc.

5. Extensively injured eyes, especially if already infected, or eyes which contain foreign bodies which all reasonable attempts have failed to remove.

6. Eyes which cause so-called sympathetic irritation, for example, chronic iridochoroiditis, old injuries, staphylomas, etc.

7. Traumatic iridocyclitis, in order to prevent sympathetic ophthalmitis, or to hasten its cure if it has already begun, provided the exciting eye itself is blind.

8. General infection of the eyeball, or panophthalmitis. (For exceptions, see page 903.)

9. Eyes blind from any cause, provided they are of themselves very painful, even though they are not producing sympathetic irritation.

Operation of Enucleation.—The following instruments are necessary: A stop speculum, fixation forceps, dissecting forceps, strabismus hook, and a pair of scissors curved on the flat. The patient being fully anesthetized (enucleation is perfectly feasible, although not always entirely painless, with local anesthesia), the lids are separated in the usual manner with a stop speculum, and the surgeon divides the conjunctiva and adjacent fascia in a circle as close as possible to the margin of the cornea, and separates it as far as the insertion of each rectus tendon. Beginning with the superior rectus, each tendon is raised upon a strabismus hook and divided close to the sclera. Next, the eye is made to start forward by inserting the stop speculum somewhat more deeply, while the surgeon introduces the curved scissors between the severed conjunctiva and the freed eyeball, follows the curve of the latter until the optic nerve is reached, where the blades are expanded and the nerve seized and cut close to the sclera. The attachments of the oblique muscles and the remaining tissue which cling to the eyeball are finally severed. By this method the eyeball is removed without injury to the capsule of Tenon and the underlying tissues. It is often known as Bonet's method (Fig. 472).

A very rapid enucleation may be performed according to the Vienna method, as follows: In the right eye, for example, the tendon of the internal rectus, together with the overlying conjunctiva, is seized with forceps, divided, and the stump retained in the grasp of the instrument. With scissors the inferior and superior rectus are next severed, together with the overlying conjunctiva. The globe is drawn forward, rotated outward, and the optic nerve divided. The operation is concluded by cutting the external rectus and the two oblique muscles close to the globe. The same operation may be begun by incising the conjunctiva a few millimeters from the corneal margin and pushing it backward, and then, in succession, dividing the muscles in the manner already described.

In recent years the technic of enucleation has been greatly improved, and modified. In complete enucleation, in general terms, these modifications reside in the management of the divided tendons, which formerly

were allowed to slip backward and the severed conjunctiva united by interrupted sutures or a purse-string suture, or, as some surgeons preferred, and some unfortunately teach even at the present time, allowed to remain unsutured. If, however, each rectus tendon is fastened to the margin of the conjunctiva, and at the completion of the operation is secured in this position, the tendons retain a firm hold upon the stump and increase its movements, which are transmitted to the artificial eye which rests upon it.

After removal of the globe by any of these methods the hemorrhage is usually slight and can be checked by pressure. The socket should be thoroughly irrigated with a 1:8000 bichlorid solution and dressed in the usual manner with a pad of gauze held in place by a figure-of-eight gauze roller. Usually the patient should remain in bed for forty-eight

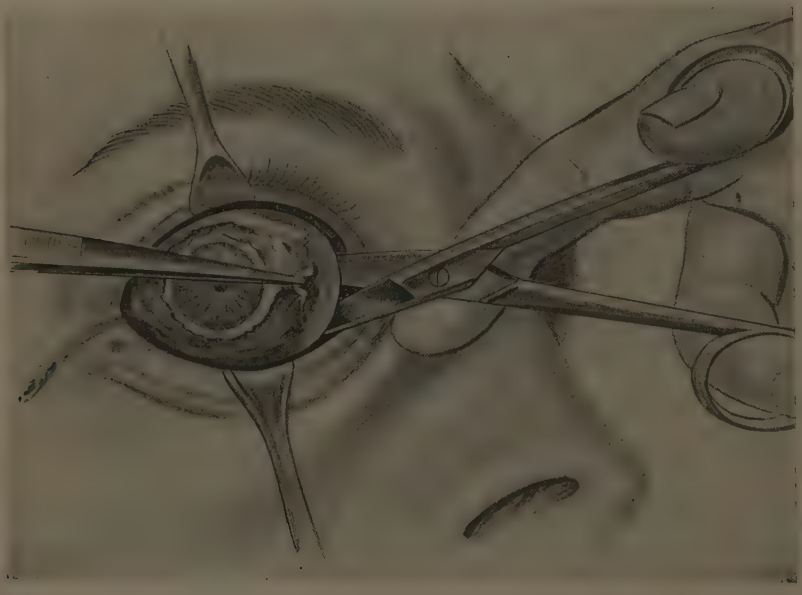


FIG. 472.—ENUCLEATION OF AN EYEBALL (after Haab).
The globe has been rotated to the extreme right and the optic nerve is being divided with the scissors.

hours. The sutures should be removed on the third or fourth day, and an artificial eye adjusted at the expiration of two weeks.

Very occasionally severe hemorrhage follows an enucleation, generally as the result of some anomalous distribution of vessels. It practically always can be controlled by packing. It is difficult to seize the bleeding point with a hemostat, although this may be tried. In one or two cases of very severe and recurring bleeding, filling the socket with melted paraffin has proved efficient.

Complications following the operation are uncommon. A few cases of meningitis after enucleation of a non-suppurating globe have been reported, but the rarity of this affection is attested by the report of an English committee formed to investigate this matter. Among 10,734 cases col-

lected from various sources, not a single instance of meningitis was recorded. Indeed, enucleation during panophthalmitis may be performed almost with impunity. Thus, in 2873 cases collected from various sources, 278 of them being for suppurative diseases of the globe, there was only one fatal case of meningitis. Three others are reported, but the records do not indicate whether the deaths occurred after an enucleation for panophthalmitis or for some other cause.

In place of enucleation, certain substitutes have been proposed. Three may be mentioned:

(*a*) Evisceration of the eyeball.

(*b*) Evisceration of the eyeball with the insertion of an artificial vitreous (Mules's operation).

(*c*) Enucleation of the eyeball followed by implantation of an artificial globe in Tenon's capsule (Frost-Lang operation).

Evisceration of the Eyeball.—This operation is performed as follows: After introduction of the speculum, the conjunctiva is loosened around the cornea and the anterior chamber transfixed with a knife on a level with the horizontal meridian. The lower portion of the cornea is separated and the flap seized with forceps, while the remainder of the cornea is severed at the corneoscleral margin. With a small scoop the contents of the globe are evacuated and its cavity thoroughly wiped out with sterilized cotton-wool until all bleeding is stopped. Finally, the edges of the conjunctiva are united by means of a suture similar to the string which draws shut a pouch, or, if preferred, by interrupted catgut sutures, which may include the conjunctiva alone, or with it the sclera.

As may have been inferred, the chief indication for evisceration is panophthalmitis, because it is believed that the danger of meningitis is lessened. As has been shown, however, in a previous paragraph, this complication is a rare one, even when complete enucleation is performed. I believe that if the purulent process has reached a great height and the eyelids and conjunctiva have participated in the swelling, particularly if the purulent infiltration has begun posteriorly, as in certain varieties of septic iridochoroiditis, evisceration is probably a safer operation than complete enucleation, but otherwise enucleation is the preferable surgical procedure. The operation is contraindicated in sympathetic ophthalmitis, malignant disease, marked phthisis bulbi, ossified choroid, and foreign bodies which have penetrated the orbit, and, indeed, has no advantage over ordinary enucleation except under the conditions already named. There is apt to be excessive reaction, the stump may attain a certain amount of tenderness, and sloughing of the sclera occasionally occurs. In my investigation of this subject in an analysis of 478 operations reported from various sources, I found five cases of sympathetic trouble following evisceration, but with the exception of two cases, which themselves are open to doubt, the records do not prove that sympathetic inflammation was caused by the operation.

Evisceration of the Eyeball with the Insertion of an Artificial Vitreous (Mules's Operation).—The operation is performed as follows: The stop speculum having been introduced, the conjunctiva

is dissected from its scleral attachments in all directions as far as the equator of the eyeball, without disturbing the insertions of the ocular muscles. The cornea and 1 mm. of the adjacent scleral margin are removed and the contents of the globe emptied with a scoop, great care being taken to obtain a perfectly clean scleral cup. After hemorrhage has been controlled a glass or gold sphere of such size that it may be inserted within the scleral cavity without difficulty is introduced, and the operation concluded by stitching the sclera vertically and the conjunctiva horizontally, in such a manner that the glass or gold sphere is covered very much as the leather covering of a ball includes its contents. Both eyes should be bandaged and the patient required to remain in bed for at least four or five days. Occasionally there is marked reaction, with chemosis of the conjunctiva, which is controlled by continuous application of cold and light pressure bandage. The operation is indicated in ruptured or injured eyeballs, if the sclera is not too much lacerated, in staphyloma of the cornea, in absolute glaucoma, in buphthalmos, and in non-traumatic iridocyclitis. It is contraindicated in suppuration of the eyeball, morbid growths, marked phthisis bulbi, sympathetic disease and pathologic conditions of the eyeball which are likely to produce it, in very extensively injured eyeballs, and in the presence of dacryocystitis, and in aged patients in whom prolonged convalescence is undesirable.

Enucleation of the Eyeball Followed by the Implantation of an Artificial Globe in Tenon's Capsule (Frost-Lang Operation).—This operation is performed as follows: The eyeball is enucleated in the manner already described, and after all bleeding has been checked a gold or glass sphere, from 8 to 10 mm. in diameter, is inserted within Tenon's capsule. Over this the capsule and conjunctiva are sutured, with silk sutures, the tendons of the ocular muscles having previously been secured in the manner described under enucleation.

Numerous modifications of this operation have been devised, which consist chiefly in the application of the sutures and the management of the severed ocular muscles. So, too, in place of a glass or gold sphere, good results are attained by the use of suitably sized paraffin balls which are placed within the capsule. The superior rectus muscle is next sutured to the inferior by a mattress suture and the two lateral muscles treated in the same manner. Tenon's capsule is united over the globe by means of a catgut purse-string suture and finally the conjunctiva is closed in a similar manner.

Introduction of an Artificial Eye.—After simple enucleation an artificial eye may be inserted at the end of the second or third week, occasionally at an earlier time, and after any of the other substitutes for this operation at a somewhat later period, or as soon as the stump is perfectly free from irritation. The ordinary shell-shaped prosthesis, or artificial eye, has been greatly improved by the introduction of the so-called *reformed artificial eye*, which consists of a double-walled shell, the smooth, rounded contour of which prevents the accumulation of mucus beneath it, and the bruising of the stump which is occasioned by the thin edges of the old-fashioned artificial eye. It is undoubtedly true that a

successfully performed Mules's operation furnishes the most perfect stump, and the rotations of the artificial eye are sometimes almost equal to those of the normal eye. It is also true that a successful implantation of a globe within Tenon's capsule yields a far more mobile stump than one after an ordinary enucleation, but with the modern artificial eye, after a properly performed enucleation with suture of the tendons, the movements are nearly as good as those which follow either Mules's operation or the Frost-Lang operation. At one time I was accustomed to perform Mules's operation in all suitable cases. I have, however, largely abandoned it because of the greater reaction which follows the operation and the fact that the ball is sometimes extruded, and confine my operations to simple enucleation with suture of the tendons, or implantation, and am satisfied with the cosmetic results.

OPERATIONS ON THE ORBIT.

Cellulitis or Abscess of the Orbit.—This affection, when it is not traumatic in origin, may be caused by the exanthemata, meningitis, erysipelas, and by extension of inflammation from the surrounding sinuses, or may arise as the result of a metastasis in the course of general septicemia. Its prominent symptoms—severe headache, exophthalmos, edema of the lids and conjunctiva, and a point of fluctuation—usually render the diagnosis easy (Fig. 473).

Fig. 473.—Cellulitis of Orbit and Great Edema of Lids (from a patient in the University Hospital).

Occasionally the pus points in the conjunctival sac and may be evacuated by an incision through the conjunctiva between the ball and the side of the orbit, care being taken not to injure the ocular muscles and to secure good drainage afterward. In deeper situations the purulent focus is best reached by a curved incision made over the orbital ridge which divides the periosteum, which is next separated with an ordinary bone elevator, kept well between the bone and the periosteum, thus avoiding the levator, the tendon of the superior oblique, and the lachrymal gland. If pus does not immediately present, the depth of the orbit must be explored with a probe until the pocket of pus is found, and evacuated by an incision through the periosteum. Drainage may be secured with iodoform gauze or an ordinary drainage-tube. The position of the original incision is determined by the probable situation of the pus, that is to say, whether it is made along the upper, lower, inner, or outer orbital margin.

If the source of the pus is from the ethmoid, the orbital plate of this bone should be perforated, carious bone and necrotic tissue removed, and a drainage-tube carried from the orbit, through the ethmoid, into the nose, which not only secures an adequate drainage, but permits the subsequent washing out of the tract.

Removal of Tumors and Cysts from the Orbit.—Tumors in the anterior portion of the orbit may be reached by an incision similar to that already described in connection with deep-seated purulent pockets, and the growth removed by an ordinary dissection. Occasionally, in favorable situations, such growths may be reached by a dissection through the conjunctiva. If the growth is an angeioma and is encapsulated, it may often be removed in similar manner by a slow dissection, without much loss of blood. If non-encapsulated, and especially if it protrudes and involves the skin of the lid and brow, it is a much more difficult procedure. To a certain extent the hemorrhage can be controlled, as Knapp suggests, by pushing a horn spatula beneath the upper lid, between the eyeball and the orbit, which may be manipulated to act as a controller of hemorrhage, while the dissection proceeds from the skin surface. Although the main body of the angeioma may thus be removed, it is often impossible, without sacrifice of too much tissue, to extirpate those portions of it which involve the skin of the eyelid and eyebrow. These, however, may disappear later, or may be treated by electrolysis. Recent investigations indicate that they may be successfully treated by applications of liquid air. In rare instances encapsulated sarcomata, endotheliomata, and certain non-malignant growths, especially in the anterior portion of the orbit, may be reached without sacrificing the eyeball, according to a method advocated by Lagrange and Knapp, namely: first severing, if, for example, it is on the inner side, the internal and perhaps the inferior rectus, which are secured with threads, next separating the conjunctiva, and gradually dissecting out the growth through the opening thus made. After controlling the hemorrhage the severed recti muscles are sewed in place exactly as in the operation of advancement. Generally, however, growths of this character are reached more easily by resection of the orbital wall in the manner presently to be described. Orbital cysts, dermoids, serous or blood cysts are treated in the same manner as growths, the dissection proceeding either through an incision along the orbital margin, or, if con-

FIG. 474.—PURULENT DISEASE OF ETHMOID AND FRONTAL SINUS, WITH FISTULOUS OPENING AT INNER ANGLE OF ORBIT (from a patient in the University Hospital).

ditions are favorable, through the conjunctiva, great care being taken to remove every particle of the cyst wall, often a difficult procedure. Occasionally a serous cyst may be cured by simply evacuating its contents and creating, as Buller suggests, a reactive inflammation by the introduction of a crystal of iodin.

Exostoses and osteomas growing from the wall of the orbit, or pushing their way into it from the ethmoid or frontal sinus, may be reached by an ordinary dissection through an incision along the orbital margin, with the usual precautions to avoid the pulley of the superior oblique, the tendon of the levator, and the lachrymal gland. When the body of the growth is fully exposed, it may be chiseled from its position in the ordinary manner, or if it is very dense and resisting, its base may be perforated several times with a drill suitably attached to a dental engine. It is next broken from its position with a stout pair of forceps, all rough spicules of bone carefully smoothed away, and the wound closed.

Resection of the Temporal Wall of the Orbit (Krönlein's Operation).—This operation, recommended by Wagner and practised by Krönlein first in 1887, has been a great advance in the surgery of the orbit because of the free exposure of the retrobulbar space which it affords.

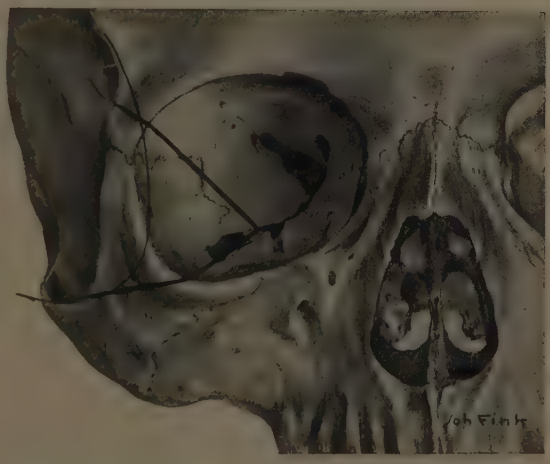


FIG. 475.—SKIN INCISION (CURVED LINE) AND BONE INCISIONS (HEAVY LINES) IN KRÖNLEIN'S OPERATION (Haab).

Technic of the Operation.—In general terms the operation may be understood from an examination of three illustrations taken from Haab's "Operative Ophthalmology" which accompany this description, also modified from that given by this surgeon. The operation begins by dividing the soft parts with a curved incision (Figs. 475, 476, 477), which should be about 7 cm. in length in adults and 4 to 5 cm. in children, which commences above the supraorbital margin and describes a gentle curve along the outer edge of the orbit to the upper edge of the zygoma, where it is bent backward and ends at the center of this structure. The center of this curved incision should bisect a horizontal line which connects the outer canthus with the outer orbital margin, and here should be sufficiently deep to expose the opening of the orbit, while above and below only the skin and fascia and muscular layer are at first divided. Next, at a position corresponding to the central portion of this incision, a strong elevator is introduced with which the periosteum is separated

from the external orbital wall. The inferior orbital fissure is now localized, and beginning at the anterior end of this fissure the bony wall of the orbit is cut through with a chisel or with an electric saw up and out to a point a little above the external angular process of the frontal bone, the line of incision being, for all practical purposes, along the suture between the great wing of the sphenoid and the malar bone, and outward and forward over the external surface of the malar bone in a line above the insertion of the zygomatic arch. Thus a wedge-shaped piece of bone is formed, and with its muscular and cutaneous attachments is forced backward, giving free access to the orbit, which will be still partly covered with the periosteum. The latter must now be split from before backward and separated with retractors. This brings into view the external rectus muscle, and if necessary this may be divided near its tendinous insertion after the introduction of sutures, with which later the divided ends are united, or sometimes the muscle may be pushed aside and the dissection continued to the apex of the orbit. With suitable retractors the orbital fat and ocular globe are pushed aside. After the exploration is complete, and this must sometimes be carried to the nasal side, and the growth removed, the osteoplastic flap is replaced, the periosteum stitched with fine catgut sutures and the soft parts with silk. The question of drainage must be decided by the conditions remaining after operation. The usual full antiseptic dressing is applied, great care being taken that the lids cover the cornea, especially if the latter structure is anesthetic.

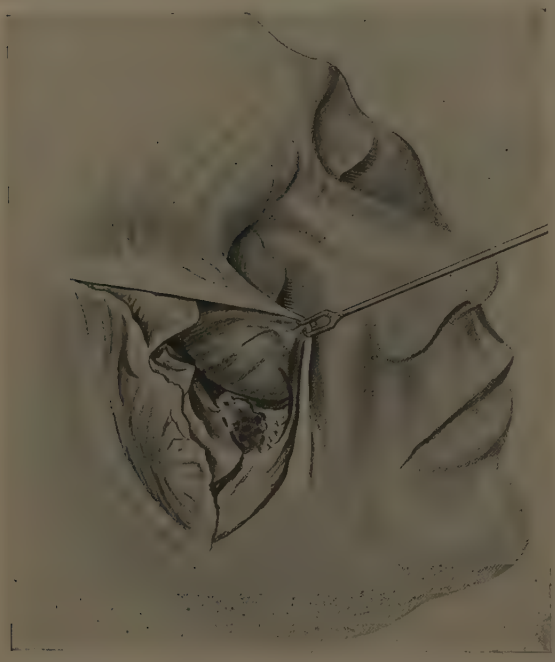


FIG. 476.—KRÖNLEIN'S OPERATION (after Haab).

The skin-muscle-bone flap has been reflected forward and shows a large portion of the periorbita. The latter is then incised from behind forward, producing the picture shown in the next illustration (Fig. 477).

Many modifications of this operation have been devised, which are well summarized by Haab in the work to which reference has been made. Various complications have occurred after this operation; for example, outward limitation of the eye owing to injury to the abducens, ptosis, sinking of the eyeball, and infection.

Indications.—Domela, Haab, and other writers have classified the indications for Krönlein's operation as follows: Retrobulbar cysts; tumors of the optic nerve and its sheath; neurofibroma of orbit (Parker); retrobulbar vascular growths, for example, cavernous angeioma, lymphangeioma, aneurisms and varicose dilatations of the orbital veins; deep-seated foreign bodies in the orbit and exploration of the orbit in doubtful cases in order to establish a diagnosis. The operation has also been performed in deep orbital abscess, to open the sheath of the optic nerve in choked disc, and even for the removal of subretinal effusions. The last two indications are of doubtful value; certainly in choked disc a far better operation is a decompression-trephining.

Extirpation of the Whole Contents of the Orbit.—This operation is designated *evisceration* or *exenteration* of the orbit. It is performed as follows: First, the outer angle of the lid should be divided with straight scissors for at least a centimeter beyond the edge of the orbit; next, with a strong scalpel, beginning at the outer orbital edge, an incision is made through the soft parts from the conjunctival sac around the entire margin of the orbit, so directed that, together with the soft parts, the periosteum is incised through the entire circumference of the incision. With an elevator, or the blade of a strong pair of scissors, the periosteum is gradually separated from the entire surface of the orbital cavity, which thus keeps within it the mass of tissue that is to be removed until the apex of the orbit is reached, where there remains only the cone-shaped mass held at this point by the tissue passing through the optic nerve entrance, which is next divided with a strong pair of curved scissors. A good deal of care must be taken in separating the periosteum from certain thin portions of the orbital walls, particularly in the region of the inner orbital wall, lest

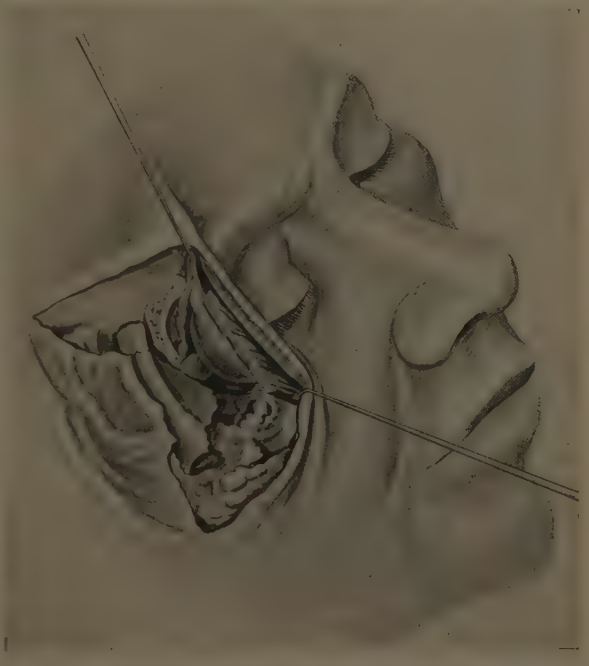


FIG. 477.—KRÖNLEIN'S OPERATION (after Haab).

After the periorbita has been divided, the deeper tissues are dissected out so as to bring the posterior portion of the globe and the optic nerve clearly into view. The large wedge of bone that has been chiseled out is also distinctly recognizable from its orbital side as far as its apex.

perforation of the bone follow. Bleeding is sometimes considerable from the tissues along the orbital fissures and at the orbital apex. This may be controlled by packing or by touching the bleeding points with a Paquelin cautery. The entire cavity, which if the operation is successfully performed presents the appearance of the orbit in the bony skeleton, is packed with gauze. If the lids are unaffected, the cilia and ciliary margins may be cut away and the lids united as two skin flaps would be over the orbital entrance, with the exception of a small portion at the outer angle, through which the end of the gauze packing protrudes, which can be removed within a few days, and replaced with a small drainage-tube until healing is complete. In a certain number of instances, however, the lids themselves are involved, as, for example, in a carcinomatous process, and must be sacrificed. Under these circumstances, as has been suggested by Langenbeck, Krönlein, and other surgeons, the gaping front of the orbit may be covered by a skin flap obtained from the forehead. Finally, it is the practice of some surgeons, and I have followed this very successfully in a certain number of instances, not to sacrifice the lids, if they are uninvolved in the disease for which the operation is performed, but after granulations have formed over the entire cavity, to cover these gradually with Thiersch grafts, which usually grow with great ease, and ultimately present a skin surface upon which it may be possible to place a large prosthesis.

Indications.—The indications for this operation are involvement of the orbital tissues in a sarcomatous or other malignant growth which has perforated the eyeball, or which has recurred after the eyeball has been removed, and malignant growths which have involved the eye and the surrounding orbital tissues, and which have proceeded from the tissues of the orbit themselves, the periosteum, or the lachrymal gland, and occasionally the surrounding skin, as, for example, in certain types of rodent ulcer and epithelioma.

Operations for Prosthesis in Cases of Cicatricial Orbit.—Contraction of the conjunctival sac and the formation of cicatricial bands, especially after lime-burns and trachoma, may render the introduction of an artificial eye impossible. The same state of affairs may be brought about by the neglect to wear a suitable eye. Numerous operations have been devised to enlarge the socket under these circumstances, mere incisions of the contracting bands being entirely unsatisfactory. If there is complete closure, or practically complete closure, of the orbital cavity, the most satisfactory results are reached by dissecting loose the attachments of the lid to the contracted orbital tissues and preventing readhesion by the introduction of grafts of skin—either a Wolfe-Lefort flap or a Thiersch graft. It is usually best to restore only one cul-de-sac at a time, and after the flaps are in place their position in the cul-de-sac should be maintained by the insertion of a plate, which, as John Weeks suggests (and he has elaborated by far the best of these operations), may be made of flexible rubber, such as is used by dentists. If the cavity of the orbit is not entirely obliterated it is sometimes possible, after dividing the cicatricial bands, to form a socket in which later an artificial eye may be

placed, by introducing lead plates, which are bent to conform to the size of the cavity, and from time to time increased in size. The plate gradually creates a groove in the dense tissue, into which afterward the margin of the artificial eye is fitted.

OPERATIONS ON THE LIDS.

Removal of the Meibomian and Other Cysts.—A very common affection of the eyelids is due to a chronic inflammation of a Meibomian gland and the tissue which surrounds it, forming the so-called *chalazion*, which presents as a somewhat firm swelling attached to the tarsus, over which the skin is freely movable, and which is evident by a discolored patch upon the conjunctival surface. The easiest method of its removal is to evert the lid so that the discolored patch is made prominent, incise with a sharp scalpel, and thoroughly remove the sac-contents with a small curet (Fig. 478). A few drops of cocain render the operation practically painless. Occasionally these growths present externally, and they may be removed most effectually, after securing the lid in an ordinary lid clamp, through a skin-incision, afterward closing the small wound with interrupted sutures. Small cysts in the ciliary margin may be cured by simple incision and curetting.

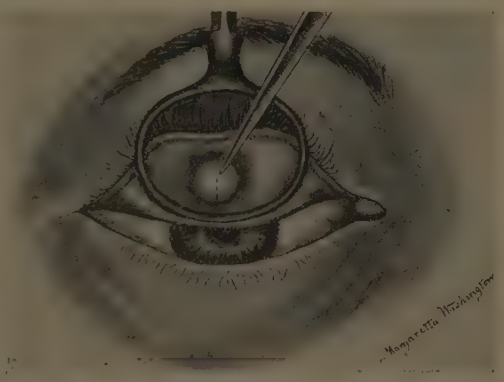


Fig. 478.—Incision of Chalazion (after Czermak).

Operations for the Relief of Ptosis.—Ptosis, or drooping of the upper lid, is either congenital or acquired, and may be partial or complete. Congenital ptosis is due to defective action or development of the levator palpebræ; acquired ptosis, to paralysis or paresis of this muscle from disease or injury, and in slight degree to tumefaction of the lids, and chronic conjunctival diseases, for example, trachoma. In the effort of raising the lid the occipitofrontalis and superior rectus act as accessory muscles. If the levator is defective or functionally inactive, the patient endeavors to raise the lid with the aid of the frontalis, hence the characteristic wrinkling of the brow, which is a marked feature in ptosis (Fig. 479).

In order to select a suitable operation for the relief of ptosis, the amount of power residing in the levator, or whether it has any activity at all, must be ascertained. The surgeon, standing in front of the patient, firmly depresses the eyebrow with his thumb, and requires the subject to open his eye. Any movement of the lid must be due to the levator, as the pressure on the brow checks frontalis action; entire failure of lid elevation indicates absence of levator power. If, the frontalis action

still being checked and the levator power absent, there is a slight elevation of the lid when the eye is rolled upward, it is due to the action of the superior rectus, from which a band passes to the levator tendon.

All operations for ptosis, and many have been devised, may be gathered into three groups, following a convenient classification recently elaborated by Grimsdale and Brewerton: (1) Those which shorten the lid or levator; (2) those which utilize the action of the frontalis muscle; (3) those which utilize the action of the superior rectus.

To the first group belong an elliptic excision of a portion of the skin of the lid—an operation no longer performed, on account of its inefficiency; shortening of the levator tendon, as practised by Bowman; folding or doubling of the exposed levator tendon on itself, and bringing it to the anterior surface of the tarsus by means of loop sutures, as devised by Everbusch and De Lapersonne; advancement of the levator tendon, as designed by Wolff and modified and improved by Elschnig; and excision of a semilunar piece of the tarsal cartilage, uniting the edges of the wound with sutures, as advised by Gillet de Grandmont, which is a modification of an operation long ago suggested by Bowman.

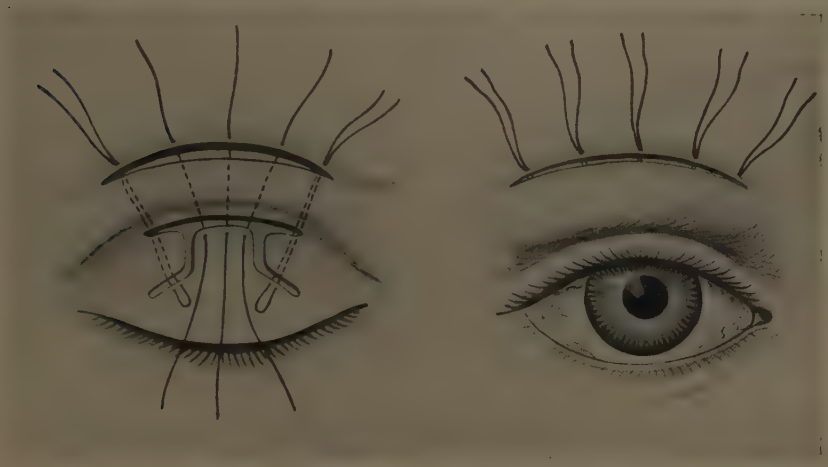
Fig. 479.—Ptosis (from a patient in the University Hospital).

To the second group belong:

I. Certain subcutaneous thread or wire operations, which act by establishing a contracting cicatrix or supply an artificial tendon. Thus, Pagenstecher's operation is performed by passing one needle of a double-armed suture subcutaneously for 2 mm. parallel to the ciliary margin. Next, the same needle is re-entered at the point of exit and passed between the tarsus and brought out above the brow. A second needle is introduced at the point of entrance of the first, and passed upward beneath the skin to the point of exit of the first one above the brow. Finally the sutures are tied. It is suited only to cases of incomplete ptosis of congenital origin. This operation has been modified and elaborated by the late Mr. Mules, who embedded a fine loop of gold wire in the tarsal cartilage, the two ends from which passed out through the frontalis, and which remained and acted as an artificial tendon. This operation has in turn been modified by Worth, who uses kangaroo tendon for his suture, and by Harman, who employs "wove chain" made of fine wire and passes it subcutaneously from the lid margin to a point above the brow.

II. Certain operations designed to form a union between the skin of the lid and the frontalis muscle. Among these, Panas' operation is well known, and consists essentially in forming a small cutaneous flap

from the lid, which is passed through an incision under the brow and is attached to the fibers of the occipitofrontalis muscle, which have been divided by an incision immediately above the brow, and which has cut through all tissues down to the periosteum. The steps of the operation



FIGS. 480 AND 481.—PANAS' OPERATION FOR PTOSIS.

may be understood by a reference to the accompanying illustrations (Figs. 480 and 481).

Somewhat similar in effect is an operation designed by Tansley, which is a modification of one devised by Hunt, and which is performed as follows: "Two perpendicular and parallel cuts, A, B, C, D (Fig. 482), one-

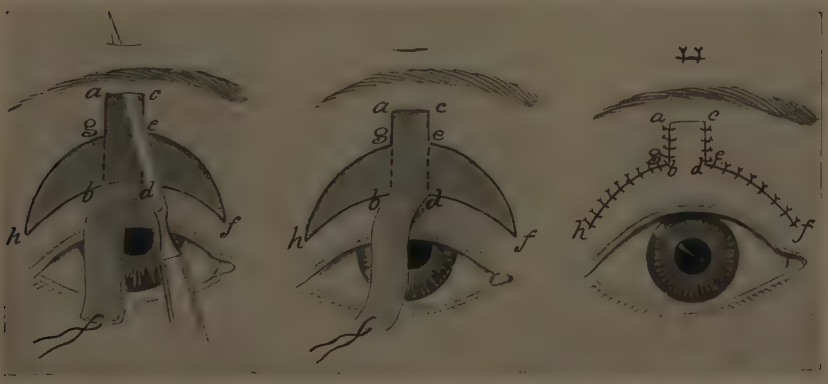


FIG. 482.—TANSLEY-HUNT OPERATION FOR CONGENITAL PTOSIS ("Trans. Am. Opth. Soc.," 1895).

quarter of an inch apart, are made, and extend from the upper orbital margin to within two lines of the upper edge of the lid. These cuts are united at the upper extremity by a horizontal incision, A, C, and the ribbon of tissue is dissected up and permitted to drop down upon a wad of cotton lying on the cheek, which is kept moistened with a warm anti-

septic solution. Next a curved cut is made from H to G and from E to F, following the crease which shows the upper limit of the tarsal cartilage, and a straight cut is made from H to B and from D to F, parallel to and about two lines distant from the lower border of the lid. The skin and the orbicularis embraced within these cuts are now carefully dissected off, leaving the whole tarsal cartilage denuded of tissue, The cut edges H, G, and E, F, are united to the cut edges H, B, and D, F, respectively, by interrupted sutures. Next a narrow Graefe knife is entered at A, C, and passed beneath and brought out upon the forehead just above the eyebrow, and slight lateral cuttings are made so as to give room for the passage of the ribbon of skin which has been dissected up at the first stage of the operation. A strong suture placed in the upper edge of this ribbon of skin is used to draw it up into the cut made beneath the eyebrow and bring it out upon the forehead. When it is drawn up sufficiently tight, it is cut off smooth with the forehead and fastened there by two small sutures. Then several sutures are placed from A to G and C to E, uniting the edges of the ribbon to the bordering derma." The operation can be readily understood by reference to the illustration.

Fig. 483.—Ptosis, Showing Stitches in Tansley-Hunt Operation (from a patient in the University Hospital).

With this operation I have had very satisfactory results.

In place of the operations just described, the procedure of Hess receives the commendation of many surgeons. It consists essentially in making an incision along the shaved brow, through which the lid-skin is dissected from the orbicularis muscle, and passing sutures from without inward through the upper part of the dissected skin of the lid, and carrying them upward underneath the skin to a point above the brow incision, where they are tied. Cicatrization of the wound surface fixes the artificial fold in the upper lid, and the union with the lower part of the frontalis transfers its action to the lid.

After any of these operations the usual dressings should be applied and the sutures removed at the end of a week. The anesthesia may be local or general.

Other operations belonging to this group are W. H. Wilder's procedure, who folds upon itself the tarso-orbital fascia and establishes a firm adhesion between the fascia and the frontalis muscle; Fergus' method of attaching a strip of the frontalis to the lid; and Sourdille's modus operandi, by which the levator tendon is fastened to the frontalis.

III. Those operations which depend for their effect upon a utilization of the action of the superior rectus. Among them the one most

frequently employed is that designed by Motais, which consists essentially in attaching a narrow tongue of tissue, formed from the center of the tendon of the superior rectus through an opening in the conjunctival surface of the everted lid, to the upper border of the tarsus, where it is fastened by means of sutures which are brought out through the tarsus and the lid-skin and tied on the outer side of the lid. While this operation has certain attractive features, it may be followed by temporary diplopia and depression of the eyeball. If the sutures are tied over the conjunctiva, the knot may cause local irritation, and has sometimes produced a corneal ulceration. If the tendon of the superior rectus is poorly developed, W. T. Shoemaker suggests that the entire tendon of the rectus muscle, in place of a single, central strip, shall be fastened to the tarsus in the manner described.

Operations for Trichiasis and Entropion.—**Trichiasis,** characterized by a malposition of the lashes, so that they are turned inward against the eyeball, generally depends upon blepharitis and trachoma. If only a few lashes are misplaced, they may be systematically removed with an epilating forceps, or destroyed by *electrolysis.*

If there is a decided trichiasis, associated with entropion, it is generally necessary to perform some one of the various transplantation operations, and at one time the Jaesche-Arlt method was much advocated, in which all of the lashes were isolated by means of an intramarginal incision, while from the surface of the lid a semilunar flap of skin and subcutaneous tissue was excised. To the upper margin of the skin wound thus remaining the bridge of tissue containing the lashes was stitched. Often disappointing in its results, this operation has been substituted by various types of *double transplantation operations,* in which, in general terms, a lid border is manufactured by transplanting to the intermarginal space a strip of skin, or of mucous membrance, as Van Millingen proposes.

Hotz's operation, which is a modification of that devised by Anagnostakis, in my experience is so valuable that I prefer it to all others. As it is practically the same as that which is performed for entropion, the reader is referred to this description (page 916).

Entropion may be either spasmodic or organic. If spasmodic, as it is often seen in elderly persons, and consists of an incurling of the margin of the lid so that the lashes sweep against the eyeball, it may be mitigated by excising a fold of skin, together with the subjacent fibers of the orbicularis muscle, of sufficient width to evert the lid into its proper place, and closing the wound with interrupted sutures, or the inverted lid may be drawn down with strips of gauze fastened with collodion to the cheek.

If the disease is organic, and, like trichiasis, has followed chronic inflammatory conditions of the ciliary margin and of the conjunctiva, for example, trachoma, it is necessary not only to evert the misplaced border, but to alter the curve of the thickened cartilage, without which success will not be obtained. Space does not permit even the mention of the numerous modifications of operations of this character, and I must be contented with the one with which I have had the best results,

namely, the Hotz-Anagnostakis operation, which is described in Hotz's own words and illustrated with his own diagrams: A transverse incision from canthus to canthus is made through skin and subjacent tissues, but instead of being made near and parallel with the free border (as in the former methods), the incision in this operation is to follow the *upper* border of the tarsus. It therefore describes a slight curve, beginning and ending at a point about 2 mm. above the canthus, but being 6 to 8 mm. distant from the free border in the center of the lid. While an assistant is holding the edges of the wound well separated, the surgeon lifts up with forceps and excises with scissors a narrow bundle of the muscular fibers which run transversely along the upper border of the tarsus. Now the sutures, which are to include nothing but the cutaneous wound borders and the upper border of the tarsus, are inserted. The first suture is placed in the center of the lid; the curved needle, armed with fine black aseptic silk, is passed through the lower wound border; there taken again in the

FIG. 484.—HOTZ-ANAGNOSTAKIS OPERATION.

needle-holder, it is boldly thrust through the upper border of the tarsus, and returned through the tarso-orbital fascia just above this border; and, finally, it is carried through the upper wound border (Fig. 484, *a*, *b*). One similar suture is placed at each side of the central one, and these three stitches are usually sufficient for the purpose—to wit, to draw the skin of the eyelid up toward the upper border of the tarsus and establish a firm union between these parts. This artificial union produces a slight tension of the tarsal skin, which, however, is sufficient to relieve any ordinary degree of entropion.

But where the lids have been badly contracted, that is, the palpebral aperture has become unnaturally narrow, or the free border of the lid has become entirely merged into the plane of the conjunctiva—these complicated cases require, in addition to the above operation, such surgical measures as canthotomy, the restoration of the free border either by grooving the tarsus or by grafting.

Tarsorrhaphy.—This operation is designed to shorten an abnormally wide palpebral fissure (*lateral or angular tarsorrhaphy*), or to close temporarily the lids over the eyeball (*median tarsorrhaphy*).

Angular tarsorrhaphy may be performed as follows: A horn shield is introduced beneath the lids at the outer commissure, and a flap 1 mm. in width and 4 to 5 mm. in length is removed, and beyond the inner end of its removal the ciliary margins are denuded for several millimeters, (Fig. 485, *b* to *c*), but the cilia themselves allowed to remain along this line of denudation. The denuded edges are approximated by silk sutures. Median tarsorrhaphy is accomplished by denuding the ciliary margin of the center of each lid for 4 mm., the lashes being untouched, and approximating the denuded edges with a mattress suture. The eyeball is thus effectually covered, but the cornea can be inspected if the globe is rotated either inward or outward through the narrowed lid interspace on each side of the central attachment.

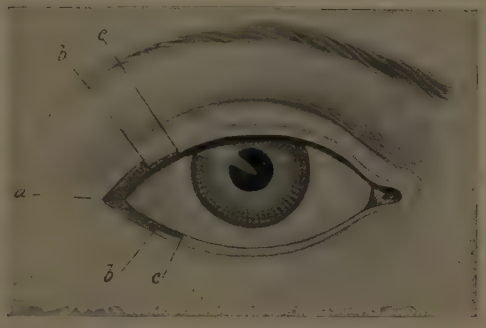


FIG. 485.—LATERAL TARSORRHAPHY.

Indications.—Angular tarsorrhaphy is indicated in ectropion in order to raise the angle of the lid and adapt it to the globe, and in lagophthalmos and exophthalmos to improve the unsightly appearance and to protect the cornea from undue exposure. Median tarsorrhaphy is suited to those conditions in which the cornea must be protected, for example, in certain ulcers (exposure keratitis), in facial palsy, and to prevent ulceration after removal of the Gasserian ganglion.

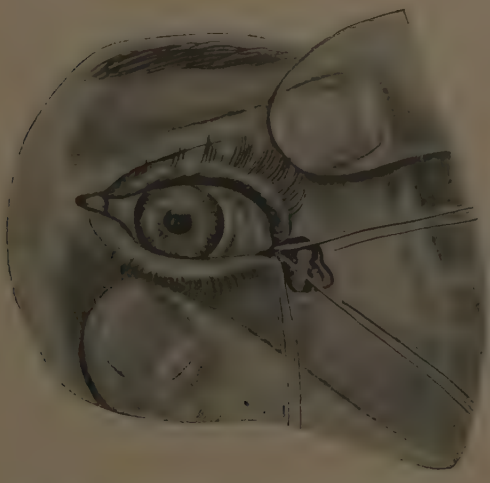


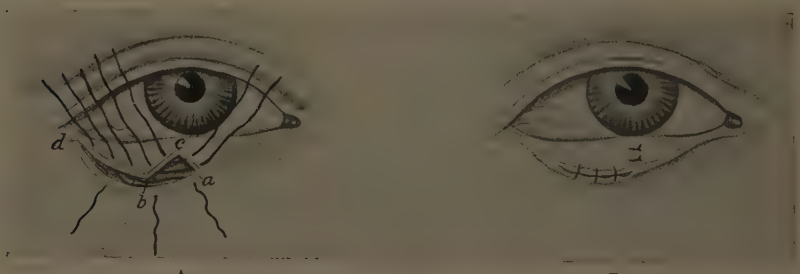
FIG. 486.—CANTHOPLASTY. THE STITCHES READY TO BE TIED (Haab).

Canthoplasty.—Under certain circumstances it is necessary to enlarge the palpebral fissure, and for this purpose the operation of canthoplasty is performed as follows: One blade of a pair of probe-pointed scissors is inserted behind the external commissure and the tissues divided to a point just beyond the margin of the orbit in such a manner that the wound in the skin is

a little longer than that in the conjunctiva. From between the wound margins, which are gently separated, the conjunctiva is loosened at the apex of the incision and freed from the underlying tissue so that it forms a triangular flap. One suture unites the extremity of this flap to the center of the skin incision, and one suture is passed above and below, uniting the sides of the triangle to the edges of the skin wound (Fig. 486). Occasionally the stitches are omitted, and under these circumstances the operation is known as a *canthotomy*.

Fig. 487.—Adams's Operation for Ectropion by Excision of a V-shaped Piece of the Lid.

Indications.—Canthoplasty is suited to those conditions in which an enlargement of an abnormally short palpebral fissure is desired, or to lessen the tension on flaps in various types of blepharoplasty. It is frequently performed for the relief of the contracted fissure which follows long-standing granular lids, or in other inflammatory conditions of the lid margins, as, for example, in certain types of chronic blepharitis.



A B

Fig. 488.—Kuhnt-Müller Operation.

Operations for Ectropion.—What operation should be performed for the relief of ectropion depends upon whether the condition is caused by a relaxation of the tissues or results from their contraction. In ordinary senile ectropion due simply to relaxation, fairly good results may be obtained by excising a V-shaped piece of the whole thickness of the lid and uniting the wound margins either with pins, very much as they have been used in harelip operations, or with sutures (Fig. 487). If in

addition to the relaxation of the tissues there is considerable eversion of the lower conjunctival fold, with thickening of the exposed mucous membrane, a good procedure is the following:

Kuhnt-Müller Operation.—With a broad, triangular knife a deep incision is made into the center of the lid-margin, which divides the lid-

Fig. 489.—Wharton Jones' Operation for Ectropion.

substance into two portions, the one containing the conjunctiva and the tarsus, and the other the soft tissues and the skin. From the first portion a triangular piece is removed by the aid of two incisions which should converge toward the fornix (Fig. 488, A, *ac*, and *bc*). The two portions of the lid are next separated toward the external canthus by carrying the knife from under the margin *bc* toward *d*. Next the V-shaped wound

Fig. 490.—Restoration of the Lower Lid by Dieffenbach's Method.

The diseased tissue has been removed in a triangular flap, *a*, *b*, *c*. This defect is covered by a flap taken from the cheek, indicated by the dotted lines, *b-d*, *d-e*, with the result shown in the right half of the illustration. The remaining gap may be covered with Thiersch grafts.

of the tarsus is closed with sutures, and the long stretch of the skin margin, *da*, is united with the shorter margin, *db*, of the tarsus by means of sutures. Their method of application may be understood by examining Fig. 488, B. The puckering which occurs after these sutures are tied disappears and the lid margin becomes smooth.

For spastic ectropion *Snellen's suture operation* may be tried. One needle on a double armed suture is made to pierce the junction of the external and middle third of the lid close to the posterior border of the tarsus, and is passed beneath the skin to a point at the summit of the

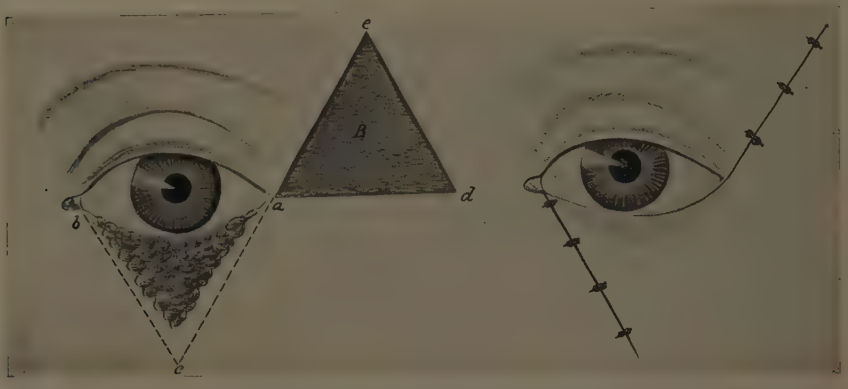


FIG. 491.—RESTORATION OF LOWER LID BY BUROW'S METHOD.

The diseased tissue is removed with the flap *a*, *b*, *c*. The horizontal incision is prolonged upon the temple and forms the base of the triangle *a*, *d*, *e*. This flap (*B*) being removed, the cutaneous flap, *a*, *c*, *d*, is dissected up and drawn inward so that the angle *a* is sutured at the point *b*, and *a*-*d* forms the free border of the lid. *c*-*a* is now united with *c*-*b*, and *d*-*e* with *a*-*e*, with the result shown in the right half of the illustration.

lower margin of the orbit, and is there brought out. The second needle is entered at a point 5 mm. from the first, and with the other end of the thread is carried down close to the first and parallel with it. The two extremities of the suture are tied upon the cheek over a piece of drainage-tube. If necessary, the same procedure may be repeated with a second double armed suture at the junction of the inner and middle third of the conjunctival surface.

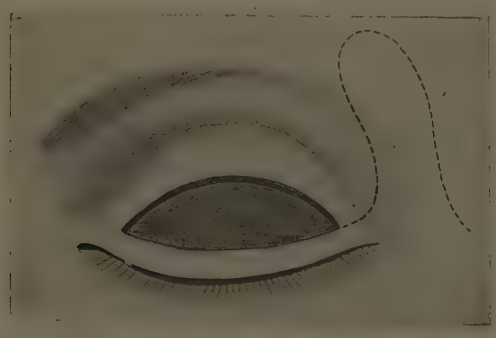


FIG. 492.—RESTORATION OF THE UPPER LID BY FRICKE'S METHOD.

The diseased tissue has been removed in an oval flap. The resulting gap is covered by a similarly shaped flap taken from the temple, indicated by the dotted line.

Blepharoplasty.—Organic ectropion, or such as results from the contraction of cicatrices after burns, or wounds or abscesses, caries of the margin of the orbit, disease of the malar bone, etc., usually require extensive plastic operations, in which the vicious cicatrix is embraced in the incision, and during which denuded areas must be covered by filling the gap with tissue transplanted from the forehead, temple, or cheek. Many ingenious operations have been devised. The site and character of the lesion must determine the method of procedure, which is carried out on exactly the same principles that

govern operations of plastic surgery in the face elsewhere described. The accompanying illustrations of a few of the most important of these operations indicate better than words can the lines of incision, both for the removal of the growth and the covering of denuded areas.

During operations of this kind the field of operation should be irrigated frequently with a tepid saturated solution of boric acid, and after the flaps have been adjusted and stitched into place with fine silk sutures, there should be a free irrigation with physiologic salt solution. Next the flaps are covered with protective, and over this several layers of antiseptic gauze secured with a few turns of a roller bandage. The dressing need not be removed for seventy-two hours, and great care must be taken in lifting it from its position lest the flaps are disturbed. Exfoliated epithelium should be trimmed and the edges of the flap anointed with boric acid ointment. At this time any area which remains uncovered by the skin flap may be covered with Thiersch grafts. These, too, may be applied if any portion of the flap should slough after the sloughing tissue has been separated. Occasionally there is a necrosis of the upper layer

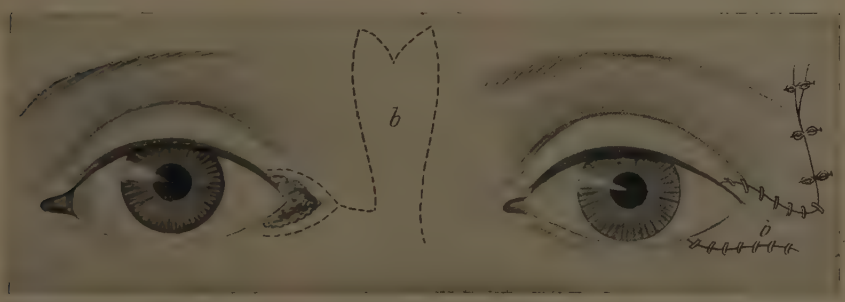


FIG. 493.—RESTORATION OF THE EXTERNAL ANGLE OF THE LIDS BY HASNER D'ARTHA'S METHOD.
The diseased tissue is removed by two elliptic incisions, and the defect covered with a flap taken from the temporal region at (*b*), cut in the manner indicated by the dotted line, with the result shown in the right half of the illustration. The same operation applies to the inner angle, the flap being taken from the nose.

of the flap without loss of life of its deeper portions, and, as Gifford has suggested, this necrotic area may be scraped away until healthy tissue is reached, upon which Thiersch grafts are planted.

Transplantation of Skin without a Pedicle.—Blepharoplastic operations, while often successful, leave not infrequently large and disfiguring scars, and to obviate this the plan originally introduced by Lefort and Wolff may be followed, namely: *Transplantation of skin without a pedicle:* In this operation a piece of skin, which must be at least one-third larger than the spot it is intended to cover, is removed from a distant part, preferably the inner side of the arm or the inner side of the thigh. After its removal it is shaved down so as to be as free as possible from subcutaneous tissue and fat, and is kept constantly bathed in tepid physiologic salt solution until it is stitched in place. After the dressing is applied it should be kept moist with tepid physiologic salt solution. These skin flaps are often of great service, especially after removal of small

growths from the lower lid, burns, and the like. In place of utilizing Lefort-Wolff flaps, Thiersch's method of skin grafting may be employed.

OPERATIONS ON THE TEAR PASSAGES.

Of the various operations which are performed upon the lachrymal apparatus, **dilatation of the punctum lachrymale** and **canaliculus,** and **slitting this structure,** are the simplest. To perform the first, the lower lid is drawn down and out with the thumb, and a silver, blunt, conical probe inserted into the punctum and gradually insinuated, after it has been depressed into a horizontal position, along the canaliculus until it reaches the lachrymal bone. If it is considered necessary to slit the canaliculus, this instrument is now withdrawn, and a canaliculus knife passed in exactly the same way, beginning in a vertical and assuming a horizontal position, until its probe point touches the inner wall of the lachrymal sac, when it is raised to a vertical position with the cutting blade turned slightly inward so as to divide the roof of the canaliculus and yet keep the cut in such a position that it can drain the lachrymal lake. Next, if there be obstruction of the ductus ad nasum, a probe is passed in precisely the same way until it touches the lachrymal bone, when it is raised to the vertical position and gradually insinuated into the duct, taking a direction which is downward, slightly backward, and outward. If it reaches an impermeable stricture, it may be necessary to incise this either with an ordinary blunt-pointed canaliculus knife, or with a specially devised stricturotome. Small probes are tried first and gradually increased to larger ones. Some surgeons believe in the introduction of very large probes, 10 to 12 mm., a procedure which I have never found satisfactory and rarely justifiable.

Indications.—Dilatation of the canaliculus without slitting it is performed to facilitate the introduction of the point of an Anel syringe in order to irrigate the canaliculus, the sac and the ductus ad nasum. This procedure should always be tried before more radical measures are undertaken. Such dilatation and washing out of the duct is often of great service in the treatment of chronic blepharitis, chronic conjunctivitis with tumefaction of the puncta, and to improve the drainage in a number of inflammatory conditions of the eye associated with great epiphora; it is advisable in simple epiphora, provided no other good cause can be found, for example, nasal disease. Even if probes are passed, it is not usually necessary to slit the canaliculus, as they can be introduced through the dilated punctum, unless large sized probes are required, when the roof of the canal must be divided.

If pressure over the lachrymal sac causes a flow of pus to appear at the mouths of the puncta and escape into the conjunctival sac, *dacryocystitis* is present; that is to say, an inflammation of the lining of the lachrymal sac, always associated with stricture of the nasal duct, which, indeed, generally antedates its appearance. If the process is an acute one, there may be chill, fever, great swelling of the lid, and extreme tenderness over the region of the sac, with the formation of an abscess (*lachrymal abscess*)

which points below the tendo oculi. Under these circumstances free purging, and repeatedly placed hot carbolized compresses, may cause resolution; or, after slitting of the canaliculus, drainage may be secured into the nose by the natural passages; often, however, it is necessary to incise the abscess in the ordinary manner, evacuate the pus, and after the inflammation has subsided, treat the conditions in the ordinary manner. The irrigating fluids under these circumstances may be bichlorid and boric acid lotions, or ordinary nitrate of silver, 1 per cent.*

If dacryocystitis becomes chronic and there is a constant overflow of tears mixed with pus, giving rise to a chronic inflammation of the surrounding conjunctiva in the form of the so-called *lachrymal conjunctivitis*, while it may be possible to cure the case by systematic probing and irrigating through the canaliculi the inflamed tissues with the various antiseptic lotions and the silver salts just recorded, by far the best and simplest procedure is:

Extirpation of the Lachrymal Sac.—A number of methods of exposing the sac have been proposed, those that are most familiar being the Voelker-Kuhnt procedure and the ones designed by Axenfeld, Müller, and Krauss. Other methods will be found in Czermak's work.

Kuhnt makes a 1.5 cm. incision directly along the crista of the frontal process of the superior maxilla down to the bone. Next he cuts with the scissors the ligament at its insertion in the crista. Following this, the capsule of the sac is opened at the anterior crista and the sac is brought to view.

Axenfeld calls his method the subperiosteal, which in many respects resembles the Kuhnt-Voelker method, but differs from it in this respect, that the incision is placed anterior to the crista and the dissection is made subperiosteally, much aided by a special method of checking bleeding. The chief incision passes nasalward from the inner lid angle, beginning somewhat above the internal canthal ligament, about 2 to 3 mm. anterior to the crista lachrymalis, in a curved manner downward and outward in a length of about 2.5 cm., directly to the bone, the periosteum of which is divided. After the incision a matter of first importance is to check the bleeding; otherwise it is difficult to recognize the structures. A Müller's wound-speculum, to which Axenfeld has added somewhat larger teeth, is utilized to draw the lips of the wound asunder in a horizontal direction. Next there is placed in position the speculum which Axenfeld has designed, by means of which the upper and lower angles of the wound are drawn apart, the pressure at the same time causing a checking of their freely bleeding margins. With a suitable instrument the periosteum is detached from the crista down to the fossa lachrymalis, the blade of the instrument being so passed that it goes posteriorly, and the nasal wall of the lachrymal sac, together with the greatest portion of the posterior part, is freed to the nasolachrymal duct. Next the upper portion (including the capsule) is seized with the forceps, loosened, and divided from its attachment with scissors. Finally, the remaining attachments are loosened down

* If argyrol (25 per cent.) or protargol (20 per cent.) is used, great care must be exercised lest the fluids escape into surrounding tissues and stain them black.

to the duct, which must not be cut off until the dissection has proceeded well into the canal.

I usually operate in the following manner: The skin being drawn toward the bridge of the nose, a slightly curved incision is made down to the periosteum, which extends from 4 mm. above the internal canthal ligament to 5 mm. below it, and passes along the orbital margin, the entire length of the cut being 2.5 cm. If a rapid removal of the sac is necessitated, the canthal ligament may be divided with scissors, and while the lips of the wound are separated, the temporal lip being especially drawn outward, the fibrous expansion from the tendo oculi is divided through its whole length, exposing the sac, which usually can be recognized by its bluish color. The sac is next gradually separated from the periosteum, being dissected out very much in the manner of removing a cyst, care being taken not to rupture its walls. The internal surface, the upper end, and the posterior surface of the sac having been freed, the tissue is cut through at the commencement of the nasal duct. It is not necessary to divide the tendo oculi in order to expose the sac, but that it can be dissected out from underneath the tendon (Fig. 494).

FIG. 494.—EXPOSURE OF LACHRYMAL SAC (after Haab).

After this dissection is completed, no matter what method is used, great care must be taken that every portion of the sac is removed, and the operation should be terminated by thoroughly curetting the region and the ductus ad nasum, removing all traces of mucous membrane. Three sutures close the wound, which usually heals promptly. If the tendo oculi has been severed it may be repaired by a strong suture, although I have not seen any evil consequences when this is omitted. Holmes advises that the canaliculi should be closed; otherwise a blind pocket forms at the inner canthus. They may be destroyed through their entire length by touching their lining membrane with the actual cautery. The dressing should consist of a pressure bandage placed over a light compress, and the stitches removed on the third or fourth day.

The complications during this operation are of minor importance, the most notable one being an annoying hemorrhage proceeding from the

angular vein or angular artery, which can usually readily be controlled by pressure, and which is usually prevented by the use of the Axenfeld speculum. Some surgeons who have found difficulty in isolating the sac have preceded the operation by filling it with paraffin, a detail which I have never found necessary. In rare instances keratitis has followed its performance, and failure to excise all of the tissue may cause a reappearance of suppuration.

Indications.—In general terms, extirpation of the lachrymal sac is indicated, and practically always, when properly performed, yields good results, in chronic dacryocystitis. It may be performed if conservative and ordinary surgical measures have failed, if there is an impassable stricture, if an operation on the eyeball is speedily necessary, if there is a serpiginous ulcer of the cornea, if patients are liable by virtue of their occupations to corneal injuries and therefore to corneal ulceration, if probing cannot be endured, and in the insane, who are very subject to dacryocystitis. After its performance there is temporarily a good deal of epiphora. This usually subsides with the disappearance of the associated conjunctivitis, and even if it continues is far less annoying than the constant presence of pus.

Some surgeons advocate as a second step in this operation, or one to be performed at a later period, if epiphora continues, *excision of the palpebral portion of the lachrymal gland*, which may be readily reached by causing this structure to protrude when the upper lid is everted, or by *ablation of the lachrymal gland itself*, reached through an incision along the outer margin of the orbit through the eyebrow (see page 852).

PULSATING EXOPHTHALMOS.*

Pulsating exophthalmos is characterized by a protrusion and pulsation of the eyeball (the vascular protrusion of Nunnely) and a distinct bruit heard over the eye, forehead, and cranium. Not infrequently it is associated with the presence of a pulsating mass situated at the upper and inner portion of the orbit.

History.—From 1805, when Travers recorded the first case of pulsating exophthalmos to which reference is usually made, until the middle of 1907, three hundred and thirteen cases of this affection have been placed on record, and a number of analyses of the literature have been prepared, beginning with Sattler's collection, in which one hundred and six cases are classified, based upon the records to the middle of 1880. Since the last-named date a number of papers and monographs have been published containing extensive bibliographies; for example, those by W. Adams Frost, Koehler, Nieden, Lefort, de Schweinitz, Keller, Slomann, Reuchlin, Houillon, Lagrange, and de Schweinitz and Holloway.

The earlier writers attributed pulsating exophthalmos, sometimes called aneurismal proptosis or vascular protrusion, solely to aneurism of the orbit, although they were not quite sure whether the lesion was a true

* In the preparation of this section I have received much help from Dr. T. B. Holloway.

aneurism, an aneurism by anastomosis, or an aneurismal dilatation of the ophthalmic artery in its whole course. Nélaton and Rivington first satisfactorily demonstrated that a communication of the internal carotid with the cavernous sinus might be responsible for the symptoms, and Keller, who, after Sattler and Slomann, has written the most complete monograph on this subject, contends that the term pulsating exophthalmos should be strictly limited to that disease in which such a communication of the internal carotid with the cavernous sinus has been demonstrated or is reasonably certain.

Although the most frequent intracranial cause of this disease depends upon the lesion just described, in a certain number of cases aneurism of the internal carotid, as Rivington demonstrated, and, indeed, as Keller himself points out, is interpreted by the cardinal symptoms of this affection, exophthalmos, pulsation, and bruit. A tumor of the brain, which has broken into the orbit, as well as a tumor of the orbit itself, or one which protrudes into it from neighboring sinuses, may cause symptoms which are analogous to those furnished by true pulsating exophthalmos, although a careful study should in most instances be rewarded by the establishment of a safe differential diagnosis, and the typical affection should be considered as an indication of an arteriovenous communication in so far as the intracranial cases are concerned.

FIG. 495.—PULSATING EXOPHTHALMOS (from a case under the care of Dr. Kent Wheelock, Fort Wayne, Indiana).

Etiology.—Pulsating exophthalmos usually is a unilateral affection. Among the three hundred and thirteen cases to which reference has been made, only thirty-six have been bilateral. The following conditions may cause pulsating exophthalmos: (1) Rupture of the internal carotid in the cavernous sinus; (2) aneurism of the internal carotid in the cavernous sinus; (3) aneurism of the ophthalmic artery both within and without the orbit; (4) tumors of the orbit, either those within this cavity or protruding into it from the neighboring sinuses or intracranial region. Of these conditions the first, namely, arteriovenous communication, is responsible for the greatest number of cases, which are most frequently traumatic in origin. Indeed, practically two-thirds, or 68 per cent., of the total number of cases are of traumatic origin, and therefore it is natural that more males than females are found in this class.

Among sixty-nine cases collected by myself and Holloway, there were fifty-four due to trauma, as follows: Twenty to falls with associated head injuries, seventeen to blows on the head, four either to blows or falls,

six to gunshot wounds, and seven to punctured or penetrating wounds. The right eye was affected in thirty-one and the left in twenty-six of the cases. Five of the cases were bilateral. Rupture of the internal carotid in the cavernous sinus may result not only from a direct trauma,

FIG. 496.—CASE OF BILATERAL EXOPHTHALMOS.

as, for example, a penetrating wound or gunshot injury, but from an indirect trauma, as, for example, a blow on the head, although it is possible that in some of the cases in which a basal fracture has taken place and the symptoms of pulsating exophthalmos have developed, a penetrating splinter of bone has caused the aneurismal varix. Where the traumatism has been an indirect one, it is likely that a diseased condition of the vascular system has been a predisposing factor.

FIG. 497.—CASE OF BILATERAL EXOPHTHALMOS. ENLARGEMENT OF CONJUNCTIVAL VESSELS.

Among three hundred and thirteen cases thus far analyzed, the number arising spontaneously or resulting from the growth of a tumor is eighty-three, and of these fully 80 per cent. were of spontaneous origin. The spontaneous cases most frequently occur among females, and usually develop as the result of straining efforts, coughing, or vomiting, and in persons who are predisposed to such an accident by reason of vascular disease. The subject of this affection usually has a sensation of something having given way in the head, which is followed by the bruit and later by the other well-known symptoms. Among forty-nine spontaneous cases occurring in women, fourteen have been associated with pregnancy, that is, 28.5 per cent., or about 4 per cent. of the total number. The majority of cases of pulsating exophthalmos occur between the ages of thirty and

forty. The youngest patient reported as the subject of this affection was sixteen months of age and the oldest eighty years.

Pathology and Pathogenesis.—Among the three hundred and thirteen cases reported up to the middle of 1907, it would seem that forty-three autopsies have been made, the results of which may be briefly summarized as follows:

I. Aneurism of the ophthalmic artery both within and without the orbit.

(*a*) Within the orbit, two cases (Guthrie, Du Villards).

(*b*) Without the orbit, one case (Nunnely).

II. Rupture of the internal carotid in the cavernous sinus.

(*a*) Traumatic rupture, ten cases (Nélaton, Herschfeld, Leber, Blessig, Stuelp, Grut and Tscherning, Usher, Gibson, Verhoeff and Jack).

(*b*) Spontaneous rupture of the internal carotid in the sinus, one case (Gendrin).

(*c*) Spontaneous rupture of aneurism of the internal carotid, or of the carotid in the sinus, six cases (Baron, Nunnely, Debayle, Karplus, Cantonnet and Cerise, Brandes).

III. Aneurism of the internal carotid, three cases (Dempsey, Coggin, Barnard and Rugby).

IV. Tumors, six cases (Lenoir, Nunnely, Schells, Alexander, De Bono, Van Duyse).

V. Thrombosis of the cavernous sinus and of the ophthalmic veins without certain arterial communication, although possibly present, eight cases (De Wecker, Bowman, Neff, Morton, Oettingen, Aubry, Grüner).

Six unclassified cases: (*a*) No abnormalities found, three (Harlan, Gaüran, Armaignac); (*b*) caries of orbital wall and abscess of brain (Jones); (*c*) absence of bony wall of orbit and dilatation of internal carotid (Gerhardt); (*d*) absence of a portion of the bony wall of the orbit (Ercklentz); (*e*) internal hydrocephalus and dropsy of the sheath of the optic nerve (Maynard and Rogers).*

Three of these autopsies represent atypical cases; the others typical cases. It will therefore be seen that there was a demonstrable communication which had risen either traumatically or spontaneously between the internal carotid and the cavernous sinus in seventeen of the cases, while in five others (all in Sattler's list), although an arterial communication was not certainly demonstrated, it was possibly if not probably present.

When from any cause an arteriovenous aneurism of the internal carotid in the cavernous sinus arises, the symptoms which follow are the result of increased pressure within this sinus. This leads to a stasis and dilatation of the superior ophthalmic vein, followed later by a reversal of the blood-streams in the orbital veins and the development of pulsation. The order in which the cardinal symptoms arise is first the

* The summary of these autopsies has been made from the records collected by Sattler, who reports nineteen, Keller, who reports nine, Reuchlin, two, and de Schweinitz and Holloway, fourteen.

bruit, next the exophthalmos, and finally the pulsation, although the last symptom may be delayed and the patient pass from observation, or submit to operation before it has fully developed. Not only may there be distention of the superior ophthalmic vein, which is responsible in part for the pulsating venous mass not infrequently seen at the upper and inner margin of the orbit, but also a similar distention of the angular veins and those of the lids. The close relationship of the third, fourth, ophthalmic division of the fifth, and sixth nerves to the cavernous sinus explains the frequent impairment of ocular muscle movement, and the increased pressure is the cause of the optic nerve and retinal lesions which have been noted.

Bilateral exophthalmos develops as follows: The traumatism—for example, a fracture at the base of the skull—establishes a communication between the internal carotid and the cavernous sinus upon one side, leading to distention or varicose dilatation of the orbital veins. Later there is extension of the process by the transverse and circular sinus to the venous channels upon the opposite side. In a certain number of cases which have been classified with pulsating exophthalmos, although not entirely accurately so, a portion of the osseous orbital wall was absent, permitting a transmission of pulsation directly from the brain, and the same is true of one case of internal hydrocephalus and dropsy of the optic nerve sheath.

Symptoms.—Sometimes the symptoms which are characteristic of pulsating exophthalmos appear immediately after the trauma; at other times hours, days, months, and even years may elapse before they declare themselves (Keller). Pain in the head, while not constant, is not infrequent, and may be confined to the affected side and associated with distress in the orbit.

One of the earliest symptoms is the bruit, which is variously described as a roaring, humming, buzzing, or hissing sound. It is increased by bending or stooping over, and usually modified and sometimes abolished by compression of the carotid. Stethoscopic examination of the superior portion of the orbit, of the corresponding temple, and in some instances of the whole skull, demonstrates the presence of this bruit, in the form of either a loud and blowing sound or one that is soft and feeble. The murmur may be continuous, with exacerbations synchronous with the cardiac systole, or may be intermittent. In one case (Gayet's) both types existed at different periods. According to Sattler, a *bruit de piaulement* should be regarded as a trustworthy sign of rupture of the carotid into the cavernous sinus. Not only may the bruit be modified and sometimes abolished by compressing one or both carotids, but in rare instances it is influenced by deep pressure made at the inner angle of the orbit, as it was in Schwalbach's case.

In sixty-nine cases of pulsating exophthalmos analyzed by myself and Holloway, some form of bruit is described in all except nine; in twenty-one it was systolic, in three continuous, in five continuous with systolic accentuations, while its character is not described in thirty-one of the cases, although it is stated to have been present. The exact region of this bruit is not mentioned in twenty-seven of the cases. It is stated to

have been "local"—that is, heard over the eye or the eye and temple—in eighteen of them, and "general"—that is, heard over the whole skull, or a greater portion of it—in twenty-four.

The next most important symptom is the exophthalmos, also arising early in the course of the disease and sometimes simultaneously with the bruit, and depending in the majority of instances upon the essential feature of this affection, namely, venous stasis. It varies much in degree, and is sometimes so decided that closure of the lids is impossible. In some instances they have been actually everted. The eye may be proptosed straight forward, but usually it is displaced outward and downward. Partial reduction of the exophthalmos follows pressure upon the globe, especially if at the same time the carotids are compressed. On release of the pressure the eye assumes its former position. The patient may be unable to elevate the lids, which are red and swollen, while the conjunctiva is chemotic, and in both of these structures the veins are dilated and tortuous.

Pulsation of the globe is not constantly present, although in the majority of cases it can be demonstrated. It may be actually visible, or detected only when the globe is palpated. Sometimes it is necessary to press the globe backward before the impulse is felt. Not infrequently there is a soft, compressible, pulsating tumor, usually situated at the upper and inner angle of the orbit, which transmits a thrill to the superimposed finger. In some instances a pulsation is visible in the distended angular vein and the veins of the forehead and lids. As a rule, compression of the corresponding carotid causes a diminution or abolition of the pulsation and a lessening of the size of the swollen veins.

Vision may remain normal throughout the entire course of the disease, or may be seriously affected, and sometimes blindness results. In the sixty-nine cases of the de Schweinitz-Holloway series the acuteness of vision of nineteen eyes is not stated. Of the remainder, ten eyes were blind, five eyes had light perception only, or at most counted fingers, eleven eyes a reduction of vision greater than one-half, eighteen eyes a reduction of vision less than one-half, while thirteen eyes retained normal vision.

Not only may the eye upon the affected side lose vision, but also that upon the opposite side, as has been reported by Pincus and Van Duyse, while in one case in which the right eye was enucleated, the left eye subsequently acquired pulsating exophthalmos.

Reduction of vision may depend upon corneal complications, for example, neuro-paralytic keratitis, ulceration of the cornea, vascularization, opacity and edema of this membrane, and upon striped keratitis. Hyperemia of the iris and actual iritis have been recorded. The usual causes of the blindness are optic neuritis and optic nerve atrophy.

In the series before referred to, fully 20 per cent. of the cases presented some degree of optic nerve atrophy, and practically all of the blind eyes lost their vision from this cause. The papillitis may present itself in the form of an ordinary optic neuritis, or develop into that phenomenon to which the name "choked disc" is usually applied. Retinal hemorrhages are frequent, and the retinal vessels themselves may be overdistended and

tortuous, and in one notable instance reported by Knapp, these vessels, temporarily at least, showed a series of alternating constrictions and dilatations of the most pronounced type.

Embolism of the central artery of the retina has been recorded, but in this instance it seems to have followed ligation of the common carotid.

Other causes of blindness are glaucoma and cataract, and Weisbach refers to five cases occurring in a series of two hundred and eight, in which the globe itself became atrophic, a condition of affairs not observed in the series analyzed by Reuchlin, myself, and Holloway.

The pupil is usually sluggish, sometimes dilated and fixed, and there may be partial or complete loss of accommodation. In one case recorded by Zur Mühlen, there was a left homonymous hemianopsia, associated with hemiopic pupillary inaction, the only case, so far as I am aware, in which such a condition of affairs has been described.

Naturally, the relationship of the cavernous sinus to the nerve-supply of the ocular muscles is responsible for the disturbance of ocular motility which are prominent symptoms of this disease. This may vary from paresis of a single muscle to complete external ophthalmoplegia and immobility of the globe. Exclusive of complete external ophthalmoplegia, a special involvement of the oculomotor nerve has been recorded in a number of instances, but by far the most frequent paresis or paralysis is that which affects the abducens nerve. In the de Schweinitz-Holloway series forty-eight eyes among fifty-nine cases gave evidence of some affection of the extraocular muscles, while eleven eyes escaped in so far as anomalies of these muscles are concerned.

Other disturbances of special sense are impairment of hearing, or its actual loss, although such a defect does not necessarily mean an involvement of the auditory nerve. Loss of taste and of smell have been reported, and involvement of the first branch of the fifth nerve, in one instance bilateral, although the exophthalmos was unilateral, has been recorded. Facial paralysis, or some involvement of the facial nerve, has been observed a number of times, and has also appeared as a transitory postoperative phenomenon.

A summary, therefore, of the conspicuous symptoms which may arise in the course of this disease, although not constantly present in each instance of it, is as follows: Exophthalmos, most frequently with the eye displaced outward and downward; bruit, usually heard over the eye and above the orbit, but sometimes audible over the whole skull and evident to the patient in a roaring, humming, buzzing, or hissing sound; pulsation, which may be visible or demonstrable only by palpation, or by pressing the globe backward into the orbit; distention of the veins at the inner angle of the orbit, especially enlargement of the angular vein, and of those of the lid and even of the forehead and on the surface of the conjunctiva; corneal complications, usually in the form of exposure keratitis; frequently hyperemia of the iris and rarely actual iritis; commonly hyperemia of the nerve-head, and occasionally optic neuritis and even choked disc; frequently marked distention of the retinal veins and scattered retinal hemorrhages; disturbances of ocular motility, sometimes so extensive as

to implicate all of the exterior ocular muscles, sometimes only one or other of them, the external rectus being the one most frequently affected where a single muscle is involved; occasional involvement of the trifacial, of the facial, and disturbances of taste, smell, and hearing.

Diagnosis and Differential Diagnosis.—While the diagnosis of pulsating exophthalmos itself is not difficult, it is not easy and sometimes impossible to determine the exact underlying pathologic condition. Naturally, pulsating exophthalmos suggests rupture of the internal carotid in the cavernous sinus, as it has not only been the most frequent lesion diagnosticated from the clinical standpoint, but demonstrated by autopsies.

Aneurism of the internal carotid in the cavernous sinus and aneurism of the ophthalmic artery, however, cause practically identical symptoms, although in all probability they do not produce a murmur of as great intensity, especially if it is a continuous bruit with systolic accentuations, nor as vigorous a pulsation. A differential diagnosis between extra-orbital and intraorbital aneurism of the ophthalmic artery is not possible.

Traumatism followed by unconsciousness, hemorrhage from the nose, mouth, or ears, involvement of the cranial nerves other than the ocular, and especially of the facial and auditory, would indicate an arteriovenous aneurism in the cavernous sinus as the result of basal fracture.

Although the pulsating exophthalmos usually develops on the same side as that which receives the injury, such is not always the rule; for example, in Calderaro's case, in which trauma on the right side produced right-sided exophthalmos, and later pulsating exophthalmos of the left eye. In the spontaneous cases the symptoms usually develop rapidly and general vascular changes are demonstrable.

The symptoms of vascular tumors of the orbit develop more slowly than those which are caused by rupture of the internal carotid into the cavernous sinus; moreover, the orbital tumor is usually palpable, and attempts to reduce the exophthalmos encounter marked resistance. If a murmur is present, it is generally feeble and intermittent, and is heard best over the corresponding temple. If a pulsating venous mass exists, it is situated at the outer angle, out and up or out and down, rather than at the internal angle, which is the usual position after rupture of the carotid into the sinus.

Malignant tumors are usually rapid in growth and are associated with cachexia. In doubtful cases a thorough examination should be made of the accessory cavities and sinuses.

Certain orbital encephaloceles have in the past been described as cases of pulsating exophthalmos, but in Ercklentz's case there was an absence of the murmur and no fundus vascular changes; exophthalmos and pulsation existed, the latter being the result of direct transmission from the brain. In some cases *x*-rays may be of service, especially in fracture of the skull and gunshot injuries with retention of the bullet, and possibly in demonstrating an absence of the osseous walls of the orbit.

Treatment divides itself into: (1) Ligation of the larger arteries of the neck; (2) operations upon the orbit; (3) compression of the common

carotid; (4) direct compression of the venous swelling of the eyelids and angle of the orbit; (5) gelatin injections; (6) the administration of certain drugs and rest in the recumbent posture.

Among sixty-nine cases analyzed by myself and Holloway, ligature of the common and external carotid was practised by one surgeon (Würdemann), with a cure; ligature of the external and internal carotid was practised six times with the following results: one cure (Usher, second case), two improvements (Siegrist and Lambert), one recurrence (Wiemuth), one negative result (Burghard and Pritchard), and one death; ligature of the external carotid alone was performed by one surgeon (Gifford).

In the same series ligature of the internal carotid yielded the following results: Cure once (Debayle); improvement four times (Sobernheim, Frazier, De Langlade, Pons and Cushing); negative results once (Houillon). Ligature of the common carotid and the internal carotid was practised once, with a cure (Thierry).

In the same list of cases (de Schweinitz-Holloway series), thirty-four ligatures of the common carotid on one side are recorded, with cure or improvement in seventeen, or 50 per cent., recurrence in seven, or 20.5 per cent., negative results in six, or 17.6 per cent., and deaths in four, or 11.7 per cent. In two other cases ligature of the common carotid was followed by death, but the fatal result was not due directly to the operation. In one of these cases reported by Barnard and Rugby, after carotid ligature pulsation disappeared on the tenth day, but owing to the presence of a brain abscess (the original injury having been a revolver wound), a craniotomy was performed two months later, which was the direct cause of the patient's death. In another case three months after the ligature the patient committed suicide.

The statistics just quoted may be compared with those which have been recorded prior to the beginning of the de Schweinitz-Holloway series, and which are quoted from Reuchlin's monograph, as follows: Among one hundred and sixteen cases of ligature of the common carotid, cure or essential improvement resulted in eighty, or 68.8 per cent., negative results in twenty-five, or 21.5 per cent., and death in eleven, or 9.5 per cent. If Reuchlin's results and those developed by the analysis of the sixty-nine cases to which reference has already been made are added together, the result is as follows: Ligature of the common carotid one hundred and fifty cases, with cure or improvement in ninety-seven, or 64.6 per cent., failure in thirty-eight, or 25.3 per cent., death in fifteen, or 10 per cent.

It is therefore evident that while ligature of the external, internal, and common carotid has been practised for the relief of pulsating exophthalmos by various surgeons, the last-named vessel has most often been submitted to this operation.

Reid prefers ligature of the external and internal carotid, as he believes that this procedure diminishes the chance of the re-establishment of the circulation through the external carotid. In the series previously quoted (de Schweinitz-Holloway series) this operation was performed six times,

with one cure, two improvements, one recurrence, one negative result, and one death; results, it would seem, which do not indicate that this procedure should be preferred to ligation of one or both common carotids.

Independently of any wound complications, ligature of the common carotid and of the other larger blood-vessels of the neck may give rise to disturbance of the central nervous system, which usually manifests itself as a partial or complete hemiplegia, often associated with aphasia. Thus, in thirty-four ligatures of the common carotid already referred to brain symptoms occurred five times after ligature of the common carotid, once after ligature of the common and internal carotid, and once after ligature of the external and internal carotid. Wood's patient was irritable and excited and his speech was thick, Brandes' patient suffered from left hemiplegia, Barley's patient from paresis and numbness of the left upper extremity, and Jack and Verhoeff's patient developed hemiplegia and a delirium which, with a few normal intervals, persisted until her death. Other cases of like nature might be quoted, and if to the five cases already referred to are added similar ones reported by Sattler, Keller, and Reuchlin, it will be found that approximately 9 per cent. of the total number of cases of ligature of the common carotid have been associated with one or other form of cerebral disturbance. Embolism of the central artery of the retina has also followed ligature of the common carotid (Siegrist).

In a certain number of cases of traumatic pulsating exophthalmos in which ligature of one carotid has failed to cure the disease, the vessel upon the opposite side has been tied. Among the total number of cases thus far reported, namely, three hundred and thirteen, there have been ten double ligatures. None of these double ligatures has been simultaneous, the intervals between the operations having been from twenty-four hours to fourteen months. The results are as follows: cured or improved, six; failures, two; deaths, two. No double ligatures have been performed for the relief of spontaneous pulsating exophthalmos.

Orbital Operations.—Although the importance of the ophthalmic vein in its relation to pulsating exophthalmos was appreciated by early observers, and Lansdown, in 1873, on the suggestion of Charles Higgens ligated successfully dilated vessels at the inner angle of the orbit, it appears that Henry D. Noyes, in 1881, was the first surgeon to publish *in extenso* a cure of this condition by an orbital operation, the exophthalmos and pulsation having been of spontaneous origin. He tied what he believed to be the inferior orbital vein without interfering with the carotid.

Woodward in 1894, after a recurrence following a carotid ligature performed five months previously, ligated two pulsating arteries at the inner angle of the orbit, with perfect result.

In 1897 Szimanowsky, after a failure of ligation of one carotid, suggested ligation of the distended superior ophthalmic vein, and at about the same time Golowin, unacquainted with Szimanowsky's suggestion, resorted to primary bilateral ligature of the superior ophthalmic vein for the relief of what he considered to be an atypical case of pulsating exophthalmos. Since that time Lasarew and Boden and Dollinger have ligated and resected with success the superior ophthalmic vein, previous ligature

of the common carotid having been unsuccessful, and in 1899 Golowin obtained a cure in a traumatic case following ligature of the superior ophthalmic vein after resection of the outer orbital wall. In this case there was no ligature of the common carotid.

Still later, Wiesinger performed the same operation with a cure after failure of compression and ligation of the common carotid. As a primary operation Sattler has successfully ligated and resected the left superior ophthalmic vein.

In a series of cases analyzed by myself and Holloway, sixty-nine in number, there were six orbital operations, which, briefly summarized, are as follows: (1) Ligature and excision of a portion of the superior ophthalmic vein, with cure after failure of direct compression to the local swelling, compression of the carotid, and ligation of the common carotid (Schwalbach); (2) ligation of the angular vein, with cure after failure following ligation of the common carotid and subsequent ligation of the external and internal carotid on the same side (Burghard and Pritchard); (3) ligation of the superior ophthalmic vein and extirpation of the venous ectasia, with cure after failure of local compression of the mass and ligation of the common carotid (Wiesinger); (4) excision of a portion of the superior ophthalmic vein as the primary procedure, with cure; prior to the operation the common carotid was exposed in order that it could be ligated if necessary (Sattler); (5) excision of the much-distended superior ophthalmic vein with cure, after failure of ligation of the external carotid and ligation of the common carotid (Gifford). In three cases there were orbital operations, all resulting in cure, in which, however, there was no excision of this superior ophthalmic vein. In one, after dissection of the orbit, the ophthalmic artery was ligatured, the patient having had an aneurism, partially extraorbital, of this artery (Lewis). In another, a mass of orbital tissue which projected from the orbit and the inner surface of the lower lid near the interior canthus was extirpated, and a cure resulted after repeated hemorrhages from this mass had followed ligation of the external and internal carotid and the lingual and facial branches (Lambert); in a third case deep incisions were made into the orbit, and nothing else was done. It is possible that in the last two of these cases the operation may have had some influence in producing the formation of a thrombus, or that they should be regarded as spontaneous cures.

Thus, excluding Golowin's first case, which was atypical, it is evident that among thirteen cases of orbital operation, but three of them were concerned with arterial ligature, and one of these was associated with a simultaneous venous ligature, while in another it is possible that the vessels ligated belong to the venous system. The superior ophthalmic vein was ligated seven times, the inferior ophthalmic vein once, the angular vein once, and the smaller orbital veins twice. Of these cases all were of traumatic origin except those reported by Noyes, Woodward, and Lasarew. In so far as I have been able to ascertain, all operations which have been performed on the orbit which have included ligature and resection of the superior ophthalmic vein have been successful. It would seem that this procedure should be considered before ligature of the common

carotid, with its mortality of 10 per cent. and failure of 24 per cent., is resorted to, and certainly should precede ligature af the second common carotid, provided the first operation has failed to produce the desired result. If a distended vein can be felt in the orbit, as Gifford points out, it should be the operation of choice. Thus far no ultimate unfavorable results have followed the operation, but in three cases there have been temporary, somewhat alarming "brain symptoms," with headache and slow pulse, due probably to extension of the venous thrombosis into the cranial cavity.*

Compression of the Common Carotid.—In the list of sixty-nine cases collected by myself and Holloway compression of the common carotid was resorted to twelve times, with one cure, three improvements, and eight negative results; a direct compression of the venous swelling is reported three times without result. In sixty-eight cases of digital compression collected by Reuchlin, there were fifteen cures (or 22.1 per cent.) and fifty-two failures (or 76 per cent.). This procedure achieves its best results in the cases of spontaneous origin, and if practised prior to ligature may lessen subsequent heart-strain by partially establishing a collateral circulation.

Gelatin injections have been employed, and one case is reported as cured by Reynier after a recurrence which followed ligation of the common carotid.

The administration of drugs has been resorted to by some surgeons, for example, potassium iodid and calcium chlorid (Evans); potassium iodid and the local use of adrenalin (Gasparini); trional and bromid, together with the use of cold compresses and leeches (Punzo, who was himself the subject of this disease). Although iodid of potassium has often been recommended (the Tufnell treatment), its results are not encouraging, neither is the use of bandages, leeches, and the galvanic current likely to be of service. Electrolysis and the injection of the salts of iron are not advisable.

In a few instances spontaneous cure has occurred, and in certain other cases in which a cure is attributed to remedies so trivial in their action that it is difficult to believe that they themselves could have had any positive result, the same explanation is applicable. One of these spontaneous cures, or probable spontaneous cures, occurred two years and eleven months after ligature of the right common carotid and left internal carotid, which was followed by some improvement, and another ten and one-half years after the accident, the preceding treatment having been digital and mechanical pressure.

In the presence of true pulsating exophthalmos surgical procedures should take precedence, and time is probably wasted by an attempt to cure the lesion by the administration of drugs, although injections of serum gelatin may be considered if the presence of an aneurism of the ophthalmic artery is known to exist.

* In 1874 Rivington injected 5 minims of the chlorid of iron into a venous mass which was present in his patient with exophthalmos. A small coagulum formed in the ophthalmic vein. There was much local pain, sick headache, and vomiting. The common carotid was subsequently and successfully ligated to complete the cure.

Of the ligations of the neck arteries the best results follow ligature of a common carotid. If this fails to relieve or cure the symptoms before the second carotid is tied, the operation of dissecting out and tying the distended superior ophthalmic vein should be tried.

If there is a distinct venous swelling in the orbit, with evident distention of the angular or superior ophthalmic vein, the operation of choice should be isolation, ligature, and resection of this venous channel, inasmuch as thus far, although the operations are few in number, they have been uniformly successful.

THE EYEGROUND AS A MEANS OF DIAGNOSIS OF INTRACRANIAL LESIONS.

The ocular signs of tumor of the cerebrum and of the cerebellum are chiefly concerned with changes in the fundus oculi, particularly the nerve-head, and in less important degree with anomalies of the visual field, the pupillary reflexes, the external ocular muscles, and the movements of the eyeball. Of these conditions, papillitis or choked disc is the most important, and to its manifestations and significance the present paragraphs are limited.

The Frequency of Papillitis or Choked Disc.—Papillitis or choked disc, headache excepted, is the most common general symptom of tumor of the brain. To state with entire accuracy the frequency of its occurrence is not possible, because the available material represents examinations of the eyeground at different stages; hence absence of choked disc at one examination does not exclude its presence at a subsequent one. The average frequency of papillitis in brain tumor, as recorded by Oppenheim, Gowers, C. P. Knapp, Dana, Bernhardt, Martin, Bramwell, and Weeks, is 78.2 per cent. Higher percentages, however, are found in individual series; for example, Oppenheim, 82 per cent., Annuske and Reich, 95 per cent., Kampherstein, 80 per cent. In my experience this symptom has been present in fully 85 per cent. of the cases examined.

An important analysis of six hundred and one brain tumors by J. M. Martin indicates that of neoplasms in which optic neuritis (papillitis) was present at some time in the course of the disease, those which involved the corpora quadrigemina and the crura yielded the highest percentage, namely, 100; tumors of the cerebellum and of the parieto-occipital region gave a percentage of 89; new-growths of the frontal (and those denominated general) furnished a percentage of 84; tumors of the basal ganglia a percentage of 75; of the pons and the medulla and of the temporo-sphenoidal lobes a percentage of 68; of the centrum ovale a percentage of 67; of the pituitary body a percentage of 65; of the motor area a percentage of 62; of the corpus collosum a percentage of 46.

Among seventy-six cases of brain tumor associated with choked disc in which an autopsy was made Kampherstein found the situation of the neoplasm to be as follows: Frontal lobe, twelve times; temporal lobe, six times; parietal convolutions, four times; occipital lobe, five times; epiph-

ysis, twice; third ventricle, twice; corpus callosum, three times; optic thalamus, twice; corpora quadrigemina, seven times; hypophysis, three times; fourth ventricle, once; peduncle of the cerebellum, twice; cerebellum, twenty-three times.

Leslie Paton has analyzed the records of two hundred and two consecutive cases of brain tumor observed in the National Hospital (Queen's Square), in one hundred and forty-eight of which the presence of the tumor was established by autopsy or operation. Optic neuritis (choked disc) was present in one hundred and twenty-five cases; in twelve the neuritis was exceedingly slight, while in twenty-seven atrophy of the optic nerve had already begun when the case was examined. In thirty-eight cases there was no sign of intraocular optic neuritis, and the large majority of these cases were associated with subcortical or pontine tumors. Paton's investigations indicate that in tumors of the cerebral cortex the intensity of the nerve-head change appears to vary inversely with the distance of the growth from the anterior pole of the middle fossa.

Date of Occurrence and Character of the Nerve-head Changes.—It is not possible to state accurately how soon after the development of an intracranial tumor choked disc may appear. Sometimes the whole process, from the beginning of the papillitis to its complete elaboration, occupies a few weeks; more often several months (Bruns). In a patient under my observation papillitis did not arise until a week before his death, although all the symptoms of brain tumor had been present for more than a year. Usually, therefore, an intracranial tumor must have existed for some time, and the increased intracranial tension or brain irritation for a definite period before papillitis or choked disc is evident, and, should the growth be situated in the pons, the medulla, or the corpus callosum, if the disc changes do not fail to appear entirely, they are apt to be late in development, as they are also, to a certain extent, in tumors of the frontal lobe and parietal convolutions. According to Paton, the development of neuritis with subcortical tumors generally indicates extension of the growth to the gray matter of the cortex or of the base, and with pontine tumors to that of the cerebellum. Brain-tumor optic neuritis* is a comparatively early symptom, if the visual tracts at the base of the brain are involved and it develops rapidly in cerebellar growths. Indeed, in the words of Marcus Gunn, intense double optic neuritis, with great engorgement of the papillæ, coming on quickly, suggests a cerebellar neoplasm. In experimental papilledema the changes may appear at an early date.

In a certain number of cases it is possible to watch the development of neuritis from its very earliest stages. The first symptom is increased redness of the disc and obscuration, usually of its upper and lower borders, associated with a certain turgescence and inequality of the venous circulation and beginning loss of the "light spot." Occasionally the nasal border is earlier and more obscured than the other margins in the form

* Gunn employs the term "tumor papillitis." J. Herbert Parsons suggests the use of the term "papilledema" to replace "choked disc" (Stauungspapille). Cushing prefers to retain the name "choked disc."

PLATE VIII.

Optic Neuritis (Choked Disc) and Macular Changes, from a Patient with Tumor of the Cerebellum, in the Service of Drs. Mills and Frazier at the University Hospital, Philadelphia.

of the so-called hemineuritis. Usually within a week, the obscuration of the nerve edges increases and the temporal border becomes veiled, while a distinct swelling of the nerve-head appears and the darkness and tortuosity of the veins is decidedly more manifest. At this period the difference in level between the top of the swelling papilla and the eyeground is usually not more than 1.5 or 2 D. Within the next week there is complete loss of the light spot and complete obscuration of the disc, the swelling increases, assumes a mound shape of mixed grayish-red color, and finally the form of the disc is entirely lost and its position can be inferred only by the convergence of the vessels. Not infrequently at this stage, and indeed at an earlier one, linear hemorrhages appear in the immediate neighborhood of the disc or on its swollen surface. The arteries, smaller than normal, pursue a moderately straight course and are difficult of recognition, being partly concealed by the swelling. The veins are dark in color, distended and tortuous, and pass along the slope of the elevation, often dipping into the infiltrated tissue.

The height of the papillitis varies, usually between 3 and 6 diopters. Occasionally it is as high as 8 or even 10 diopters.

At some periods of choked disc, especially in the later stages, there may be very great increase in the number of hemorrhages, both on and in the immediate neighborhood of the disc. Exudates may also appear, white or yellowish-white in color, and white patches develop in and on the swollen disc.

To distinguish a true beginning neuritis or a congestion with edema from a "spurious optic neuritis," or so-called "hyperopic disc," as it occurs in association with refractive error is often most difficult. There is, however, in the beginning of the nerve-head changes of brain tumor a certain quality which pseudoneuritis does not possess. The blurring of the disc edges is more complete, and even with the indirect method of examination the obscured margins are with difficulty seen; the surface congestion is more decided; the retinal veins, often only one division of them, are darker, more distended, and more unevenly tortuous, indeed, decided tortuosity of the retinal veins, especially of one or two of the larger branches, may appear before any obscuration of the disc. A swelling of at least 3 D. should exist before the name "choked disc" is permissible.

Ophthalmoscopic examination is not always made during the period of typical choked disc; patients may come after the evidences of inflammation and edema have begun to subside—at the period, in other words, when the veins grow less distended, new hemorrhages do not appear, previously obscured vessels reappear, and the swollen nerve-head begins to be depressed and the grayish-red tint of the prominence becomes more uniformly gray and grows paler. The temporal edge of the disc is the first to appear, and gradually the other margins emerge from the obscuration. Finally, all edges of the discs are clear, and the well-known symptoms of *post-papillitic atrophy* are present, quite distinguishable from either a *primary* or a *secondary atrophy* by the presence of the tissue which fills in the center of the disc and obscures the lamina cribrosa

so prominently visible at the bottom of the shallow cupped, primarily atrophic discs. Both sets of vessels, too, are contracted and streaked with infiltrated perivascular sheaths. Areas of retinochoroiditis and patches of white marking the spots of former hemorrhages are often apparent.

In rare instances a second attack of choked disc takes place, that is, after the original swelling of the disc has disappeared. The tendency of papillitis is to cause atrophy of the nerve, but it may remain stationary for long periods of time and finally disappear without leaving a trace of its presence. Naturally, as Oppenheim points out, such a state of affairs could be expected only if the original disease subsides, or there is relief of intracranial pressure by trephining. Exceptionally, however, as he notes, the original disease continues, but the edema and swelling subside.

In place of choked disc as a sign of brain tumor, *optic nerve atrophy* itself without indications of pre-existing neuritis or papilledema may appear. This is particularly true in the case of basal tumors, for example, of the hypophysis, and depends upon direct compression of the chiasm, the optic nerve tracts, or the optic nerves themselves. It may also be produced by bulging of the lateral ventricles and the pressure thus exerted by them. This is the so-called *secondary atrophy*. The color of the disc is gray and assumes a tint not unlike that of primary or progressive atrophy. More often the color of the disc is whiter than in gray atrophy. Both sets of vessels are contracted. This secondary atrophy must be distinguished from the consecutive or post-papillitic atrophy, to which reference has already been made. In a certain number of cases there is a period of congestion of the discs preceding the atrophy, which may or may not have been observed.

The papillitis of intracranial tumor is sometimes unilateral, and where there is a one-sided choked disc, or a marked difference between the two sides, it is suggestive of the fact that the cerebrum is the seat of the growth, and on the whole in favor of the tumor being on the same side as the excess of neuritis. J. M. Martin's investigations on this subject are important and show that the seat of the lesion is probably on the side on which the nerve-head change is more marked in the proportion of 71 to 29. Although unilateral choked disc, or, more accurately, excess of papilledema on one side, occurs in tumors of the cerebellum, it is a much less common symptom than in the cerebral cases. (Compare with page 943.)

Retinal Changes.—A very interesting appearance is the so-called macular figure, in other words, a lesion simulating that seen in albuminuric retinitis. It is said to be more frequent in cerebellar growths, but has been observed a number of times with tumors having other situations. The most perfect figure of this kind noted by me occurred with a subcortical tumor in the parieto-occipital region.

In thirty cases of tumor reported by Leslie Paton these macular changes were noted five times—one frontal case, one parietal case, two cerebellar cases, and one extracerebellar case. Kampherstein found eight times in his two hundred cases of choked disc (one hundred and thirty-

PLATE IX.

Post-papillitic Atrophy and Widespread Perivasculitis, from a Patient with Tumor of the Cerebellum, in the Service of Drs. Mills and Frazier at the University Hospital, Philadelphia.

four of these were brain tumor cases) involvement of the macula, but only once a typical star figure, such as is seen in retinitis albuminurica. Therefore, the macular involvement is not always a star figure, due probably to edematous infiltration, and is not necessarily associated with great depreciation of vision, but may be, as in Kampherstein's seven other cases, composed of smaller and larger hemorrhages or irregular white plaques of exudation. Bruns believes that these yellowish-white and fatty degenerated spots intermixed with hemorrhages are of serious import.

Other retinal changes have already been referred to, particularly areas of atrophy, marking the position of former hemorrhages, sclerotic patches in the retinal vessels, perivasculitis, pigment-heaping, which are in no sense significant of the growth itself but only of other ocular lesions which have accompanied it.

Visual Acuteness.—Papillitis or choked disc caused by cerebral growths is perfectly compatible with normal acuteness of vision.

An interesting fact is the rarity with which optic neuritis and choked disc occur in eyes that are myopic. In one notable instance with a myopia of 10 D., although all signs of brain tumor had been prominently present for nearly two years, there was no alteration of the nerve-head until ten days before the patient's death.

Differences in the visual acuteness of the two eyes are not uncommon. The vision of one eye may be normal, while that of the other may be only one-half or one-third of normal. Usually this difference, if not caused by refractive error, depends upon the degree of the disc lesions, or upon post-neuritic changes. A considerable atrophy of the nerve may exist in one eye and no apparent atrophy in the opposite eye, which possesses normal or nearly normal vision. In cerebellar growths there is apt to be early great disturbance of vision, and blindness may follow rapidly if the condition is unrelieved. The tendency of choked disc is sooner or later to cause atrophy, hence the necessity of early interference to save sight.

Temporary amaurosis in brain tumor is a sign of decided importance. Although the visual acuteness in the presence of choked disc may be entirely normal, or reach close to the normal standard, the patient may have periods of temporary amaurosis which last from a few minutes to a few hours, and, it is said, may continue for several days, to be followed by a restoration of the visual power to that which existed prior to their occurrence. They are probably due to increased intraventricular pressure, which extends to the chiasm.

Amblyopia and blindness without eyeground changes have been observed by Curschmann, Gerhardt and others, and have been attributed to the bulging forward of the floor of the third ventricle and pressure upon the chiasm.

The Effect of Operation on Choked Disc or Papillitis.—The various theories which have been advanced to explain the development of papillitis or choked disc cannot be discussed in this chapter. In general terms it may be stated that a large number of cases of papillitis represent a true engorgement edema, and that the evidence of inflammation, at least in the early stages, is lacking. Where engorgement

edema is the marked feature the ophthalmoscope reveals the typical picture of choked disc. In some cases, however, the elevation of the disc is less decided and the inflammatory condition predominates, the process extending to the retina, where exudates and hemorrhages are visible; in other words, an inflammatory optic neuritis appears to be present. Kampherstein, as the result of his own work and the review of the observations of others, declares that in our present state of knowledge there can be no absolute adherence to the theory, especially championed by Schmidt-Rimpler and Manz, usually known as the lymph-space theory; neither is it possible to explain all cases by assuming a descending inflammation which passes from the lesion in the brain to the end of the optic nerve as others are inclined to believe, nor by adopting the theory that the papillitis it not the product of an edema, but is an inflammatory affection in the sense that fluid distends the sheath of the optic nerve and possesses an irritative quality. He does believe that the condition often is best explained by a preceding edema of the brain extending through the optic nerve to the lamina cribrosa, and thus causing choking of the nerve-head. As, however, the percentage of eyes in which there is neither edema of the nerve nor distention of the interspace is a large one, it is impossible to accept alone the mechanical theory, and raised pressure sufficiently maintained must, in a certain number of instances at least, be the direct cause of choked disc. Paton regards so-called optic neuritis as a local manifestation of a general edema of the cerebral tissues due to tumor irritation. Merz, basing his opinion upon experimental evidence, declares that increased intracranial tension alone is sufficient to produce choked disc, and his results have received confirmation in the recent work of Cushing and James Bordley, Jr. As Parsons says: "All those who have had opportunities of watching the extraordinary effect of the relief of intracranial pressure upon a choked disc must agree that no theory which leaves this element out of account requires further consideration."

The important fact remains, no matter which one of the theories is adopted, that there may be a subsidence of choked disc after operation undertaken with a view to the removal of an intracranial tumor, even if the tumor is not removed. In other words, palliative or decompressing trephining is of the utmost importance and is an operation which should be practised early. Much has been written upon this subject, notably by Horsley, Bruns, Erb, Taylor, Saenger, Mills, Spiller, Frazier, Paton, Cushing, and others, and there is practical accord in their views, viz., early operation should be practised, and time employed in giving drugs in non-specific cases is time wasted. Usually there is no very decided change in the swollen nerve-head after trephining in which the dura has been opened, or after the removal of a tumor, until the seventh to the tenth day; although decrease in the general distention of the retinal circulation may be evident at the end of twenty-four to forty-eight hours. A marked lessening of disc-engorgement is sometimes evident within the first two days.

After this period there is gradual subsidence of the swelling, from four weeks to two months being required for its complete disappearance.

The ultimate vision may be (*a*) better than that which existed prior to the operation; (*b*) equal to that which existed prior to the operation; (*c*) worse than that which existed prior to the operation. Sometimes total blindness results, if the defective vision has existed long before the operation, especially if much blood is lost during the surgical procedure. In the cases with preservation of vision, either as good as or better than that which the patient possessed before the operation, the sight may be better in one eye than the other, or exceedingly defective in one eye and good in the other, or one eye may be blind and the other retain or regain excellent vision.

Naturally, the most satisfactory results follow the reduction of great intracranial pressure, provided the choked disc has not so long existed that it has already destroyed the optic nerve-fibers.

In a certain number of cases, during the first day or two after trephining, there may be a slight increase in neuritis, or, more accurately, a slight increase in edema, associated with fresh hemorrhages. This is apparently of no importance, as the added edema and fresh hemorrhages disappear in the subsequent general subsidence of the swelling.

A matter of some importance which I have noted on several occasions is temporary depreciation of vision within the first week after the operation, probably due to shock, perhaps to hemorrhage, and which is apparently of no importance in the subsequent restoration, or rather preservation, of vision, provided the primary vision has been good and the papilledema of comparatively short duration. In cases, however, in which very little vision exists prior to the trephining, for example, a vision reduced to hand movements, or even light perception only, this may rapidly disappear after trephining, especially if there has been much hemorrhage. If the nerve-head lesions are at a late stage, evident by decreased vascularity of the swollen papilla, increasing pallor of its surface, and markedly diminished caliber of the central retinal vessels, there is little use of performing any operation in the hope of saving sight (Gunn). Therefore it is important to interfere early and relieve the intracranial tension by a palliative trephining while the choked disc is in the early stages of its development. Under such conditions the prognosis *quoad visum* is most favorable.

Significance of Choked Disc.—Although the presence of bilateral papillitis or choked disc is highly significant of cerebral tumor, of itself it possesses no distinct localizing importance. In this connection, however, it is proper to quote from J. M. Martin's careful analysis of six hundred and one brain tumors that so-called optic neuritis is constantly present in cases of tumor of the corpora quadrigemina, that it is present in about 90 per cent. of cases of tumor of the cerebellum and posterior part of the cerebrum, and that it is absent in nearly two-thirds of the cases of tumor of the pons and medulla and of the corpus callosum. Unilateral choked disc, or decided excess of nerve-head edema in one eye, is usually believed to indicate that the tumor is on this side. Martin shows that the seat of the lesion is probably on the side on which the choked disc is more marked, in the proportion of 71 to 29. Paton, however, thinks this sign

cannot be relied upon, although it is respected by Gowers, Horsley and others. According to Gunn, in the majority of tumors of the frontal lobe there is homo-laterality of the choked disc, but in tumors further back the sign has little diagnostic value. The assertion of some observers that one-sided engorgement of the papilla indicates a tumor on the corresponding side situated in the temporal lobes is emphatically denied by Bruns. That temporary amaurosis may have a localizing significance and indicate a tumor of the occipital lobe, as stated by Bruns, is doubted by Oppenheim, and is contrary to my experience. Paton found the symptom most often in cerebellar tumors. No positive conclusions as to the size of the tumor can be drawn from the intensity of the choking of the disc, because although great engorgement edema may be caused by a large tumor, the reverse is sometimes true, and a small tumor may be associated with great swelling of the nerve-head. Sudden increase in the engorgement is suggestive of sudden increase in the size of the lesion or of the degree of intracranial pressure.

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CHAPTER LXVI.

MILITARY SURGERY.

By General Robert M. O'Reilly, M.D.,
WASHINGTON, D. C.

Military surgery, in its broadest sense, deals with all that has to do with the care of the wounded in war. It includes their treatment on the battlefield and at the first station of assistance, their transportation and care along the lines of evacuation, and their treatment at the base hospitals. Thus, it covers all provision for their shelter, transportation, and medical and surgical attendance from the time they are wounded until their final discharge or return to duty.

Military surgery, therefore, embraces not only a consideration of surgery proper as practised in time of war, but all methods of organization, administration, and supply connected with the care of the wounded. Many of the details of organization, administration, and supply are, however, equally applicable to and employed for the care of the sick of the army; but as these are identical with the means employed for the care of the wounded, they are properly considered under the general heading of military surgery. Therefore a consideration of the subject divides itself into two heads: (*a*) the organization and administration of the medical department; (*b*) military surgery proper, which specifically deals with the wounds received in war and their treatment.

ORGANIZATION AND ADMINISTRATION.

In early days the duty of the military surgeon was almost entirely confined to the care of the sick and wounded, but, with the advance of medicine and surgery, especially along the lines of prevention of disease, the functions of the military surgeon have been extended to include all matters pertaining to the preservation of the health of armies. The military surgeon has now to deal with all matters pertaining to the sanitation and hygiene of troops, as well as their entire care when ill or wounded. In consequence, the duties of a military surgeon are of an extremely complex and technical character and require thorough knowledge of administrative details in order that he may properly accomplish the work required of him.

The work done by a military surgeon differs in many respects from that of his civilian confrère. In civil life a surgeon has usually to look after only the medical or surgical features of his cases, his patients being housed in hospitals or in their homes, where all details relative to their food, shelter, and clothing are provided for. The military surgeon, on the

other hand, not only has to care professionally for the sick and wounded of the force to which he is attached, but has to see that they are sheltered, fed, and clothed, provided with medicines, dressings, and attendance, and transported from the field to the field hospitals and thence to the base hospitals; in addition, he has to maintain discipline among the patients and attendants, attend to their pay, and is generally accountable for the condition of the hospitals and medical equipment under his charge. All this requires that he should be thoroughly familiar with the way of obtaining supplies, shelter, and clothing, that he should know how properly to place all the units under his control, and be familiar with hospital administration and with the official channels through which all the things required by the sick and wounded can be obtained. A surgeon, however skilled he may be in the theory and practice of his profession, when attached to a military force and suddenly confronted with the many details which he is called upon to supervise and determine, will fail most lamentably in adequately caring for the sick and wounded in war unless he has the technical knowledge of administrative details which will enable him to obtain the necessary supplies, shelter, transportation, and attendance which they will require. Equally, unless he is versed in the methods of preventive medicine, he will not be able to give proper sanitary advice nor properly to supervise the general sanitation and hygiene of the command to which he is attached.

In the United States the regular army with its corps of trained medical officers is but a moiety of the force employed in war. On the outbreak of hostilities the army is increased by volunteer troops whose officers are often untrained in administrative work. When technical problems pertaining to supply and administration which require training and experience for their best performance confront such officers, they are unable to solve them properly, and there is consequently inadequate provision for the sick and for sanitation of camps. Only by careful study of military surgery in its larger sense, including as it does medico-military administration and the application of medical, surgical, and sanitary knowledge to the conditions which obtain in armies during war, can a surgeon prepare himself for the special work of a medical officer.

To this end, in the United States, Congress has provided for the instruction of medical officers of the National Guard of the different States in technical military duties by providing for their attendance at the Army Medical School. Officers from the National Guard are allowed to attend this service school, and, when graduated from it, they carry back to their regiments the knowledge there obtained, so that, if these troops enter the field as volunteers, their medical officers may be able to properly administer their departments. In the United States this is one of the most important functions of the Army Medical School, and one which it is hoped in the future will be increasingly recognized and used.

It will be impossible in the brief space allotted to this chapter more than to point out the general lines along which a surgeon must work in order to familiarize himself with the many administrative duties required of a military surgeon, but the more basic facts may be stated, and, for

purposes of study, the medical, surgical, and sanitary equipment of an army may be grouped under two general heads: (*a*) personnel and (*b*) equipment.

Under *personnel* are included the individuals comprising the medical department (including the hospital corps) and their duties. Under *equipment* are included all the appliances with which they have to work, using the term appliances in its broadest sense, embracing medicines, dressings, hospital furnishings, tentage, and transportation.

In time of peace the personnel and equipment are usually definitely fixed upon what is known as a peace footing, the personnel and equipment being distributed at different military stations according to the needs of the service. One or more medical officers, a certain quota of enlisted men of the hospital corps, and, in some cases, female nurses are stationed at established military posts. At these posts hospitals are provided with an equipment similar to the average civil hospital. In time of peace the senior surgeon is charged with the supervision of the sanitation and hygiene of the command where he is stationed and with the administration of the hospital. His duties, therefore, combine those of a health officer with those of physician and surgeon, and the enlisted men of the hospital corps under him carry on the nursing and other work of the hospital. In war a different status and order of duties obtain. These will be considered in this chapter as they most directly pertain to what may properly be called military surgery.

PERSONNEL.

In the United States Army the personnel employed in the care of the wounded, as well as of the sick, consists of commissioned officers, contract surgeons and dentists, enlisted men, female nurses, civilian employees, and officers and men temporarily on duty with the medical department during or after a battle, engaged in removing the wounded. In time of war this force is supplemented by such voluntary aid, including that furnished by the Red Cross Society, as may work with the medical department or under the surgeon-general of the army.

The commissioned personnel comprises the medical officers of the regular medical department of the army, the medical officers of the volunteer forces and of the organized militia called into service, and such officers of the line as are detailed for duty with the medical department as quartermasters or commissaries. The surgeons under contract, though not commissioned, have many of the duties and responsibilities of commissioned officers.

The non-commissioned personnel comprises the enlisted men of the hospital corps, both privates and non-commissioned officers, and the enlisted men of the volunteer forces who are enlisted in or detailed to duty with the hospital corps.

The female nurses are those employed in the nurse corps in accordance with the Act of Congress of February 2, 1901, which provides that the nurse corps (female) shall consist of one superintendent and such chief nurses, nurses, and reserve nurses as may be needed. These nurses are

appointed or removed by the surgeon-general with the approval of the Secretary of War. Their number varies according to the exigencies of the service, and they are usually employed on hospital ships and at the larger base and general hospitals.

The civilian employees include all civilians hired for work as clerks, drivers, laborers, or scavengers.

The distribution and duties of the personnel in the field depend upon the size and organization of the force to which they are attached. It is generally estimated that six medical officers are required for each one thousand troops. Of these, four officers are required at the front with troops and two are needed for administrative and other duties at the base or elsewhere.

For efficient service, the enlisted men of the hospital corps should number at least 5 per cent. of the strength of the army. Four-fifths of these should be attached to the troops at the front and one-fifth should be distributed for service at the rear, at the stationary and base hospitals, and along the lines of transportation.

The number of civilian employees, female nurses, and contract surgeons required in war can rarely be accurately determined, but must depend upon the character of the campaign, the number of wounded and like conditions which vary in different wars.

FIG. 498.—PRIVATE OF THE HOSPITAL CORPS, U. S. ARMY, WITH FIELD UNIFORM AND EQUIPMENT.

The Distribution of the Personnel in Time of War.—The assignment of duties to the personnel of the medical department depends, first, upon the organization of the fighting force; and, next, upon the particular necessities relating to the care, transportation, and supply of the sick and wounded, which vary according to the plan and execution of the campaign, the location of the seat of war, and the character of the lines of evacuation, all of which differ in different wars and therefore require some modification of disposal of personnel from that which is theoretically correct. The general basis is, however, usually closely adhered to.

For medical and surgical aid the basic units of the infantry and cavalry in the organization of a modern army are the regiments. The units of the engineer corps are the battalions; of the artillery, the batteries; and of the signal corps, the companies. These units are aggregated into brigades, these into divisions; divisions are consolidated into corps, and these together form the army.

The personnel of the medical department of the United States Army

in the field is distributed according to the subdivisions of the army above given, certain of the officers and enlisted men being assigned for duty directly with the different units of the combative force as above named, and others are assigned to duties which pertain more particularly to the general medical administration of the brigades, divisions, and corps into which the units are aggregated.

Thus, there are the regimental medical officers, the medical officers attached to the engineer battalions, the batteries of artillery, and the companies of the signal corps. In addition to these there are the surgeons assigned for duty at the brigade, division, and corps headquarters, and the enlisted men attached for duty to each of these military units, as well as the medical officers and enlisted men of the ambulance companies, the field and base hospitals, and those distributed to the supply and transport services or assigned to general inspection and administrative duties.

The Medical Personnel and Equipment for a Regiment.—As the regiment of cavalry or infantry, the battalion of engineers, the battery of artillery, and the company of the signal corps are the smallest units of a combative force supplied with medical personnel and equipment, the provision for aid furnished these units may be first considered, and in doing so it should be borne in mind that a regiment or other unit may be required to act independently or in combination with others, according to the character of the campaign in which it is engaged.

Wars may now be divided into two main groups: (*a*) war between two civilized nations; (*b*) war between a civilized nation and a semi-civilized nation or race. In war between two civilized nations a regiment or other unit is but rarely detached for service; but where a civilized nation carries on a campaign against a semicivilized or savage people, as in our late war in the Philippines, a regiment, or a battalion, of which there are three in a regiment, or even a company, of which there are four to each battalion, may be detached and operate alone. Under such conditions it is necessary that the regiment or detachment have a supply of medical material and a personnel sufficient to care for its sick and wounded independent of other aid. In wars between civilized nations, as regiments rarely act alone, they are organized into brigades and divisions, and the medical department personnel and equipment for the force are mostly aggregated into the larger units of the field hospital with its ambulance company section.

In the United States army, as now constituted for war, each cavalry regiment consists of 1286 officers and enlisted men, each infantry regiment has 1642 officers and enlisted men, each battalion of engineers 677 officers and enlisted men, each battery of light artillery 164 officers and enlisted men.

To these units medical personnel is assigned as follows: To each regiment, three medical officers—one major, one captain, and one first lieutenant; three non-commissioned officers of the hospital corps—one sergeant, first class, two sergeants; nine privates of the hospital corps—three orderlies, four nurses, and one driver: to each battalion of engineers,

two medical officers—one captain and one first lieutenant; two sergeants and six privates: to each battery of artillery and each company of the signal corps, one medical officer—captain, one sergeant, and one private, first class.

The medical equipment for these temporary units consists of medical and surgical supplies packed in regulation chests, field furniture, tentage, etc. When on detached service a "detached service chest" is issued to a regiment, battalion, or small organization for field use. This chest contains a supply of medicine in the form of tablets, diagnostic tags, clinical thermometers, a small operating case, and the more commonly required instruments, dressings, etc. When one of these smaller military units is detached for a protracted period, a regimental hospital or other sufficient medical equipment is taken.

The Regimental Hospital.—When the regiment is isolated so that patients cannot be transferred to other hospitals, a regimental hospital with capacity for caring for the sick of the regiment is provided. The regimental hospital is supplied with bedding, food-chest, medical and surgical chest, dressings, and the necessary articles for the care of the sick. Six hospital tents, two for wards and one for dispensary and operating, and three for the use of the attendants and non-commissioned officers, are furnished. The whole equipment requires two four-horse wagons for transportation and is really a small field hospital. The two tents for wards accommodate twelve patients, but, should circumstances demand, the equipment and bed capacity may be increased as necessary.

The Regimental Infirmary.—During active field service the very ill of a command are cared for in the field hospital or are sent to the base hospitals at the rear, but a regimental infirmary is provided for the temporary protection and care of the sick of the command while on the march or in camp. This care is strictly temporary, for the cases found to be serious should be promptly transferred to other hospitals so that the mobility of the regiment may not be impaired. The equipment of the regimental infirmary is similar to, but smaller than, that of the regimental field hospital, and requires one four-horse wagon for transportation. Two hospital tents, field chests containing bedding, medical and surgical supplies, and some miscellaneous articles required for the temporary use of the sick are provided in this equipment.

The regimental surgeon has charge of the regimental hospital or infirmary and is the adviser of the regimental commander in sanitary matters. It is his duty to see that the equipment of the regimental infirmary or hospital is kept complete, that all the men of the regiment are provided with first-aid packets, and that the necessary hygienic and sanitary provisions to maintain the health of the regiment are carried out. The duties of the regimental surgeon are very important, for he is in direct touch with the personnel of the army, and upon his vigilance largely depends the maintenance of its health.

The Brigade Personnel and Equipment.—A typical brigade consists of three regiments. The medical personnel of a brigade consists of the medical officers and enlisted men of the hospital corps assigned to

duty at brigade headquarters and to the regiments. The equipment consists of the regimental infirmaries. At headquarters of the brigade is assigned a brigade surgeon and one sergeant and a private of the hospital corps. The brigade surgeon is the adviser of the brigade commander in all medical and sanitary questions concerning the brigade and has general supervision of the hygiene and sanitation of the brigade. When a brigade is detached, it takes with it from the division one field hospital, complete, with its ambulance section.

The Division Personnel and Equipment.—*The division forms the basis of army organization.* It consists of three brigades of infantry, one regiment of cavalry, nine batteries of field artillery, one battalion of engineers, one company of the signal corps, the ammunition and supply columns, a pack train, and four field hospitals. Thus there is supplied one field hospital for each brigade of infantry and one field hospital for the remaining forces of the division. This allotment of medical personnel and equipment makes it possible to separate a brigade from a division and yet give such detached command a fully equipped field hospital in accordance with the field service regulations, which prvoide that "when brigades are detached they will be supplied with the due proportion of the auxiliary arms and services corresponding to their independent functions and the nature of the special service expected."

A cavalry division consists of three cavalry brigades, six batteries of horse artillery, one company of engineers, one company of the signal corps, one ammunition and supply column, and two field hospitals with light transportation. As mobility is of great importance in such a command, the field hospitals are reduced to two, and these with light transportation, so that the mobility of the command may not be too greatly impaired.

The medical personnel of a division consists of three medical officers—one lieutenant-colonel medical inspector, one major chief surgeon, one captain or lieutenant, and seven enlisted men of the hospital corps, all at headquarters of the division. In addition to these, there are the medical officers already named as attached to the brigade headquarters, to the regiments, and those attached to the field hospitals and ambulance companies. The division surgeon supervises the medical and hospital corps service of the division, including frequent inspections of the field hospitals and ambulance companies.

FIELD HOSPITALS.

The field hospital, of which there are four to each regular division and two to each cavalry division, is divided into two sections—a hospital section and an ambulance company section.

The **hospital section** includes all the personnel and equipment of the hospital proper. It has a capacity of 108 beds and is designed to be used only during active operations. The personnel of the field hospital section comprises five medical officers, viz., one commanding officer; one executive officer, quartermaster and commissary; three ward surgeons;

also fifty-seven enlisted men of the hospital corps, of which nine are non-commissioned officers. The surgeon in command of a field hospital has general charge of it and is responsible for its efficiency and the maintenance of its supply; he superintends the admission, return to duty and transfer of the patients in his hospital, and, as commanding officer of the detachment of the hospital corps, has general control of the discipline and keeps the accounts of the enlisted men on duty at the hospital. His executive officer aids him in the work of supervision and has special charge of the records. The commanding officer also usually assigns another officer to superintend the cooking and diet of the hospital, to draw rations from the

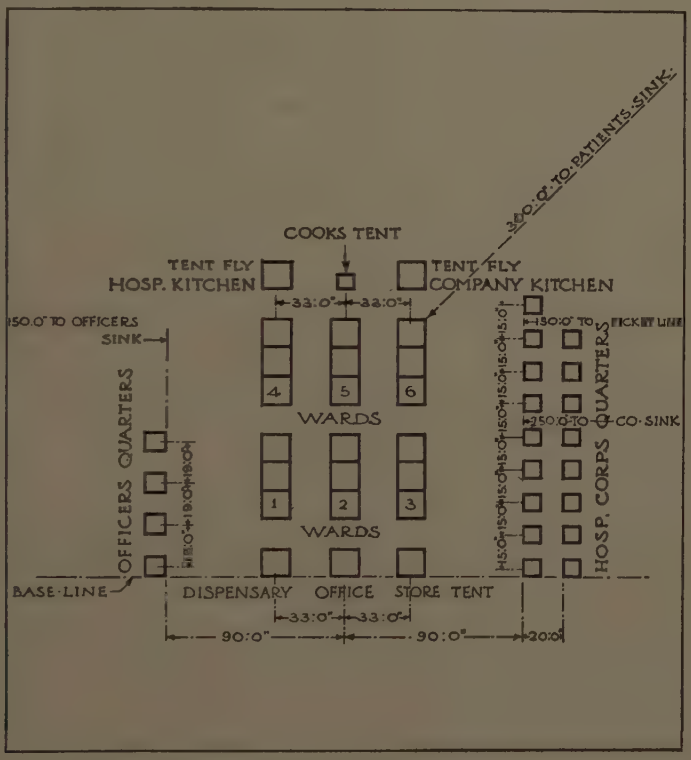

Fig. 499.—Ground Plan for a Field Hospital.

subsistence department, to keep the accounts of the hospital fund, and to have special charge of the hospital stores.

The personnel of the **ambulance company section** consists of three medical officers, one captain commanding and two first lieutenants, nine non-commissioned officers, and sixty-eight privates of the hospital corps. The ambulance company is furnished with twelve ambulances, which are to provide the transportation for the sick and wounded of the brigade, and with three four-horse wagons for the transportation of its own equipment. The medical officer commanding the ambulance company attends

to the pay, clothing, and subsistence of his men, and is responsible for the care of the ambulances, wagons, horses, mules, harness, etc., pertaining to its organization.

THE EQUIPMENT OF THE MEDICAL DEPARTMENT IN THE FIELD.

The equipment for field service consists of all materials required for medical and surgical use carried by wagon or other means of transportation, the ambulances, wagons and other transport, and the personal equipment of the members of the medical department.

Each enlisted man of the hospital corps is equipped with the articles he personally requires in the service: waist belt, to which is attached a knife and first-aid packet; canteen; haversack and field mess furniture; one half shelter-tent with pins and poles; and a blanket roll which contains extra underwear and toilet articles. If a private, he carries, in addition, a hospital corps pouch, or, if detailed as a medical officer's orderly, he carries an orderly pouch. For non-commissioned officers of the hospital corps the equipment is the same as that for privates, except that they carry an emergency case instead of the pouch.

The hospital corps, emergency, and orderly pouches are designed to meet the requirements of first-aid work in the field. The hospital corps pouch is made of waterproof lined canvas and contains aromatic spirit of ammonia, a jack-knife, field tourniquet, a roll of wire gauze for splints, adhesive plaster, sublimated gauze, six sterilized gauze bandages, four first-aid packets, and a case containing pins, scissors, and dressing forceps. The orderly pouch contains, in addition to the articles carried in the hospital corps pouch, dressings and materials that a surgeon may require in emergency work, *i. e.*, pocket case, catheters, chloroform, hypodermic syringe, ligatures, diagnostic tags, and pencil. The emergency case carried by the non-commissioned officers is of solid leather and contains the more essential medicines, such as digitalis, atropin, cocain, morphin, quinin, etc., in tablet form, and additional instruments, such as hemostatic forceps, scalpel, needles, ligatures, thermometer, etc.

The **first-aid packet** is now a part of the equipment of every officer and enlisted man in the United States army. It consists of a hermetically sealed, easily opened metal case, and is provided with hooks or loops for attachment to the cartridge belt. All the contents of this case are sterile and consist of two bandages, two compresses of absorbent sublimated gauze, and two No. 3 safety-pins wrapped in waxed paper. One compress is affixed to each bandage by sewing it lengthwise in the center of the bandage, and the bandage is then rolled from each end to the compress and so folded that the compress can be opened out without touching its inner surface. To apply it the stitch holding the folds of the compress together is broken, the compress is opened out toward the rolls of the bandage on each side and applied to the wound. The bandage is then unrolled and used to suitably attach the compress.

This new first-aid packet has many advantages over the old packet with its triangular bandage. The triangular bandage required consider-

able skill to adjust it properly to many parts of the body. The new dressing, made to be attached with the gauze bandage, is much more easily and surely applied in any region of the body.

The **shell-wound dressing** is provided for the larger wounds produced by fragments of shells, splinters, etc. It is similar to the shell-wound dressing adopted by the navy, and is supplied to the coast and siege artillery and, in certain numbers, to the field artillery. The contents of the shell-wound packet are a compress and bandage and two safety-pins wrapped in waxed paper. The compress is made from one square yard of sublimated gauze folded to make a pad 6 by 9 inches. Across the back of each end of the compress is placed a 3-inch gauze bandage 48 inches long, the two bandages being held in position by stitching along the edge of the compress. This makes practically a four-tailed bandage with an attached central compress. The dressing is sufficiently large to cover quite a large area, and the four tails of the dressing make it easy to attach it to any part of the body.

The value of these first-aid dressings for wounds received in war has been so thoroughly proved as to require no further argument for their use. All the members of the fighting force should be carefully instructed in how to handle and apply them. This instruction can best be given by the regimental medical officers during organization, previous to the time of active campaign, and each brigade surgeon should see that the regimental surgeons of his brigade instruct the men of their commands carefully in the use of these invaluable dressings. Special attention should be given to the proper opening of the cases, and especially to the handling of the dressings themselves, that the men may be thoroughly informed as to how to open and apply them without touching the part of the dressing which is to come in direct contact with the wound.

The **equipment for the field hospital** is sufficient for one hundred and eight patients. This hospital is designed to be used only during active operations, and its equipment is kept to the minimum, additional supplies being procured whenever necessary from advanced medical supply depots. For this hospital thirty-one hospital tents are provided, and one wall tent for each medical officer. The hospital tents are used for sheltering the enlisted personnel of the hospital and for kitchen, dispensary, storage, operating tent, and wards. Eighteen hospital tents are used for wards, there being six wards of three tents each, pitched end to end. The furniture consists of a folding stool and folding bedside table to each tent, four commode chests, four folding bath-tubs, and one operating table to each hospital. In a moving command no cots are prescribed, the bedding consisting of bed-sacks, pillow-sacks, blankets, and rubber blankets to be used between the bed-sacks and the ground. When the field hospital is fixed, camp cots, mosquito bars, chairs, and tables are supplied. The whole equipment for the hospital requires eight four-horse wagons for transportation.

The **equipment for the ambulance company section** of the field hospital consists of the equipment for the ambulance station (carried in its own four-mule wagon so that it can be quickly taken during action to the

designated place for the ambulance station) and of the equipment for the ambulance company itself.

The equipment for the ambulance station consists of one hospital tent, bedding and bed-clothing for eighteen patients, food chest, chests and cases containing medicines and dressings, and the other material necessary to the establishment of the ambulance station in time of action.

The equipment for the ambulance company proper consists of a large variety of articles necessary to the encampment and movement of the field hospital and ambulance company section in the field, and also of the additional litters required for use in transporting the wounded during action.

The whole transportation of the ambulance company section of the field hospital is carried in three four-horse wagons, making a total of eleven baggage wagons required for the field hospital complete with its ambulance section. With each ambulance company section of the field hospital twelve ambulances are provided, making a total of forty-eight ambulances furnished for the use of each brigade.

The **equipment for the regimental infirmary** in active service is carried in an escort wagon which follows the regiment. This equipment consists of two hospital tents, one of which is to be used for the temporary care of the sick and the other as a dispensary and office. The remainder of the equipment consists of the necessary bedding for nine patients, cases of medicines, dressings, etc.

The **transportation of patients in the field** is primarily provided for by the ambulances and litters furnished for the use of each brigade. Additional means of transportation, such as the travois, horse litters, wheel litters, etc., are sometimes used, and, following large engagements, escort wagons, farm wagons, and other means of transportation have frequently to be pressed into service.

The ambulance now used in the United States service for transporting the sick and wounded is a strong and serviceable four-wheel vehicle, ordinarily drawn by four animals in the field. It provides transportation for eight men sitting or four recumbent, or two recumbent and four sitting. It is fitted with four removable seats which are hung against the sides when not in use. When four recumbent patients are carried, two are placed on litters on the floor of the ambulance and two are carried on litters supported by means of litter-supporting posts and straps. Under the body of the ambulance are carried two ambulance boxes containing hospital stores and surgical dressings. Recently automobile ambulances have been given a trial, and it is probable that with improvement in these vehicles they will be adopted to some extent for use in peace and war. The rapidity with which patients can be transported with them in certain sections of the country where the roads are good will make them especially useful.

The hand litter used in the United States army is strong and light, weighing only about twenty pounds. It consists of a canvas bed, 6 feet long and 22 inches wide, fast to two poles 7½ feet long, held apart by two jointed iron braces. The ends of the poles form the handles, and affixed

underneath the poles are short, stirrup-shaped iron legs to support the litter on the ground or on the floor of the ambulance. A litter sling is attached at each end of the litter.

A litter squad for the usual handling and transportation of patients consists of two men, but three or four men may be assigned to a single litter whenever the conditions require.

As the equipment for the regimental hospitals or infirmaries and the field hospitals has to be kept to the minimum in order to insure proper mobility of the commands, advanced medical supply depots are located at convenient points. An **advanced medical supply depot** has a personnel of one medical officer, two non-commissioned officers, and nine privates of the hospital corps. This advanced supply depot is used to furnish deficiencies of medicine, stores, dressings, equipment, etc., arising from ordinary expenditures, unavoidable loss or damage, and other causes incident to field service. The equipment of this depot is carried in six four-horse wagons, and consists of the necessary articles to replace those used in the regimental infirmaries and field hospitals.

The complete **medical assistance for an army at the front** is therefore: (*a*) the regimental aid, which includes the medical officers attached to the regiment and the equipment of the regimental infirmary or hospital; (*b*) the field hospitals with their personnel and equipment, including the ambulance company section of each hospital; (*c*) the advanced medical supply depots; and (*d*) the officers of the medical department and members of the hospital corps attached to brigade, division, and corps headquarters. With this the provision for the medical service at the front ends.

Behind this extends the **medical assistance of the rear** with provision for the transportation of the sick and wounded from the front to the rear, the stationary hospitals and rest stations on the lines of communication, base or general hospitals at the base of operations, convalescent camps, casual camps, base medical supply depots, and the necessary means of communication between these different units. The transportation from the field hospitals to the hospitals at the rear and base is under separate command; trains and boats are under the command of medical officers who have suitable assistance and nurses. Each general hospital at the base is commanded by a medical officer under regulations prescribed by the Secretary of War. These hospitals are usually situated at such a distance from the field of operations that they are not liable to be disturbed by the incidents of war, and are therefore of a more or less permanent character and are equipped with all appliances for the best possible care of the sick and wounded.

THE MEDICAL SERVICE IN CAMP, ON THE MARCH, AND DURING ACTION.

The Medical Service of the Camp.—At the outbreak of war troops are collected in the camps of organization and mobilization. In the camps of organization the duties of medical officers are particularly im-

portant and often difficult. The troops in these camps are mostly volunteers who are unused to camp life and do not know how to properly carry out the necessary sanitation required when large bodies of men are assembled together. The medical officer has, therefore, not only to prevent the outbreak of epidemics, but to instruct the troops in the necessary camp hygiene and at the same time to organize the medical department for the active service that is to follow. The rules of camp hygiene must be rigidly enforced in order to prevent the occurrence of disease or its transmission from the sick to the well. In all wars the likelihood of the spread of contagious diseases among troops in camp, especially if these troops be raw levies, has been noted. The eruptive fevers and typhoid fever, especially the latter, have in recent wars made the greatest inroads upon the health of troops. The fact that these diseases may be spread by mild and ambulatory cases has to be constantly borne in mind by the medical officers, and every case of fever, however slight, should be isolated and carefully watched.

The medical officer must also especially concern himself with the water-supply of the camp and with the disposal of excreta. Every precaution must be taken to insure that the water is pure, is guarded from any possible pollution, and that the excreta are so disposed of that their carriage by flies is prevented. In tropical climates these provisions have to be especially rigidly carried out, the food has to be carefully watched, and, in addition, the soldier must be protected so far as possible against mosquitos, in order to prevent the occurrence of malarial or yellow fever.

In the organization and mobilization camps, in addition to the care of the sick and the sanitation of the camp, the work of preparation for the active campaign must be done. The men must be instructed in personal hygiene and in the use of the first-aid packet. The necessary supplies must be accumulated, the field hospitals with their ambulance companies organized, equipped, and prepared for field service, so that when the command moves the medical department shall be properly provided, organized, and ready to move with it. In these camps no regimental hospitals should be established. The regimental infirmary should be used as an office and dispensary where sick-call is held and where minor emergency cases are treated and those slightly and temporarily ill looked after. All other cases should be at once sent to the field hospital.

Before troops in permanent camp are sent into the field the medical officers should see to it that the field hospitals correspond with requirements for moving commands; that is, that the cots and other material used in permanent camps are disposed of and the regular equipment for the moving field hospital provided, and the medical officer in command of the ambulance section should see that the complete equipment for his company is supplied. At this time the sick of the command should be carefully examined, and all those not merely temporarily ill should either be transferred to the hospitals in the rear or left at the place of permanent camp in a satisfactory hospital there established.

With **troops on the march** the camp is usually broken soon after reveille. The commanding officer should inform the senior medical

officer in advance of time for breaking camp so that all suitable preparations can be made. It is desirable that the ill taken with the command should be fed just before the march begins, and that they should be examined and suitably prescribed for by the medical officers, and that the nurses in charge should be given their instructions and medicines for the remainder of the day. In the meantime the animals are groomed, fed, and watered, the baggage and escort wagons are packed, the patients transferred to the ambulances, and the hospital tents struck and packed. The regimental infirmary should be packed, and when the troops march should usually follow immediately in the rear of the regiment to which it belongs. The field hospitals should ordinarily march in the rear of the last regiment of the division, except that, when there are several divisions in one column, one field hospital will usually be held in reserve and march in the second line, with the ammunition column and trains, usually a short day's march in the rear. If an engagement is imminent the personnel and equipment for each dressing station (which is a part of the equipment of the ambulance company) should march at the rear of each brigade, except that the first brigade should be followed by an entire ambulance company.

On the march the regimental officers should accompany their regiment, the senior with the commander at the head, one junior with the ambulance at the rear, and the other at the rear of the leading battalion. The sick and wounded falling out in line of march should be examined by the medical officer with the ambulance at the rear, and, if they require transportation, they should be placed in the regimental ambulance. When the ambulance is filled, diagnosis tags should be given as passes to the ambulance train and other transportation, and the weak and footsore may be relieved of their equipment and permitted to march in the rear of the regimental ambulance.

At the end of the march the regimental infirmary following each regiment should be at once set up and the sick of the regiment attended to. Those temporarily ill should be suitably cared for, and those having more serious ailments should be transferred to the field hospital as soon as it is established. As the field hospital marches in the rear there may at times be delay in its arrival and establishment; in such cases the sick of the regiment should be cared for at the regimental infirmary until it is known that they may be accommodated at the field hospital. The regimental surgeon should make prompt report of the number of sick that he intends to transfer to the field hospital to the officer in charge of that organization so that upon its arrival the proper number of tents to accommodate the sick may be unloaded, pitched, and supplied with bedding and such other articles as may be needed. As soon as the field hospital arrives the necessary amount of tentage, bedding, and other articles is unloaded from the wagons, the tents are pitched, and the litter-bearers transfer the sick from the ambulance wagons. The cooks immediately proceed to provide warm liquid food and later a regularly prescribed meal. In the meantime the tents of the officers are pitched, the ambulance and baggage wagons are packed, the animals are fed, watered, and groomed, and the

men of the hospital corps pitch their shelter tents and trench around the hospital tents to keep their floors dry in case of rain. A wagon guard and hospital guard are established, the medical officers visit and examine patients and prescribe the duties of the nurses. These various duties incident to packing, unpacking, and establishing field hospitals soon become routine, each man detailed to a particular duty soon becoming so familiar therewith that he performs it quickly, and, at the end of a march, but a short time is required to establish the regimental infirmaries and the field hospitals completely and in order.

When the march is next resumed, the sick unable to proceed with the command should be transferred to the stationary hospitals, or, if this is not practicable, they may be left under shelter in houses with the necessary attendance until taken charge of by the medical service of the lines of communication, the chief of which should be duly notified, and the service of which, whenever practicable, should be constantly extended from the rear and kept in touch with the moving command at the front.

The Medical Service During Action.—The disposal of the personnel and equipment for the care of the wounded in action will depend in a measure upon the conditions under which the fighting is carried on. These conditions are three: (*a*) troops acting on the defensive behind fortifications; (*b*) troops attacking such fortifications; (*c*) mobile troops operating against a mobile enemy, as in ordinary field engagements.

In *defensive operations* within fortifications the care of the wounded involves much less difficulty than it does under any other conditions which obtain in war. Help may be rendered the wounded almost immediately as the fortifications afford considerable protection to surgeons and litter-bearers. Well equipped hospitals can usually be established in places which are well protected and not distant from the fortified lines. The wounded ordinarily have to be carried but a short distance and the difficulties and dangers incident to long transport are avoided. In consequence, the wounded usually receive assistance almost immediately after they are injured, can be quickly transported to a not far distant hospital, and can there have the careful examination, and operative treatment if required, which in field operations has sometimes to be considerably delayed. In case the fortification is carried or surrenders, the stations of medical assistance are not subjected to any such dangers as are the stations of assistance in field campaigns when they are in the path of an advancing enemy.

In *attacking a fortified enemy* there is usually ample time to distribute the personnel and establish the stations of assistance at suitable and well protected places. Usually there is little likelihood of these being disturbed, even though the attack be repulsed, unless the repulse be an exceedingly disastrous one, in which case the troops on the defensive may make a counter-attack and carry the works of the attacking force. The greatest danger is to the wounded who fall between the advance works of the besiegers and the defences of the besieged. Over this zone, unless the attack is successful, there is no possibility of bearers going to the aid of the wounded unless by mutual consent of the two forces. This con-

dition was well exemplified in the operations of the Japanese about Port Arthur, where, following the attacks of the Japanese upon the fortifications, the wounded were often left for hours or even days without assistance.

With *mobile troops in action against a mobile enemy* in the field the most difficult problems of surgical assistance are presented. The long range of modern projectiles, the destructiveness of infantry and artillery fire,

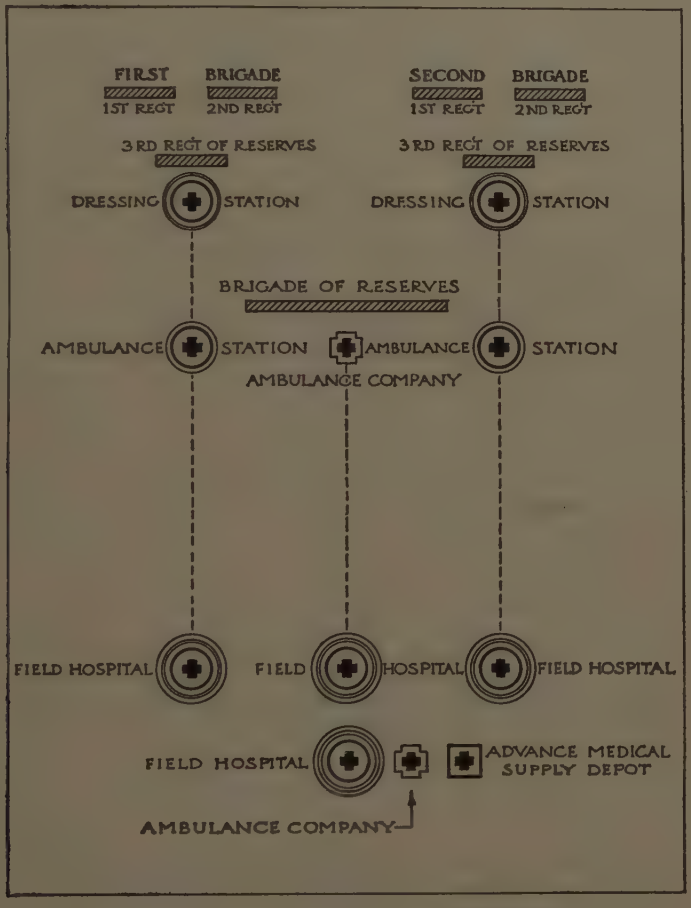

FIG. 500.—THE ADVANCED LINES OF MEDICAL ASSISTANCE IN BATTLE.

and the terrain over which the troops are operating, have all to be considered. Theoretically, the lines of assistance have been carefully worked out, and should be adhered to as far as the various conditions of the particular engagement may permit. The theoretic provisions for assistance are as follows: (*a*) the *regimental aid;* (*b*) the *dressing station* personnel and equipment; (*c*) the *ambulance station* personnel and equipment; (*d*) the *field hospital* personnel and equipment.

With troops going into battle the senior medical officers, in consultation with the responsible officer of the line or staff, dispose the medical equipment and personnel to the best advantage, and as far as possible in accordance with the above general scheme of distribution. The chief surgeon of the army or corps, when an engagement is imminent, after consultation with the commanding officer, should indicate to the division surgeon the localities best adapted for the establishment of the field hospitals, and during and after the engagement should inspect them from time to time and keep a general supervision over the dressing and ambulance stations and the movement of the wounded to the hospitals. The division surgeon having received from the chief surgeon directions as to where to place the hospitals of his division, should see that they are brought to the designated place as expeditiously as possible and there properly established. He should designate the special duties required of the medical officers of his division and assign the operating surgeons and their assistants to their proper stations. He should designate the locations for the ambulance stations of his division, and, during and after the engagement, he should directly supervise the transportation of the wounded from them. The brigade surgeon should locate the dressing stations and see that they are properly equipped, should supervise the work at them and the transfer of the wounded to the ambulance stations. The regimental surgeon (unless he has been detailed to duty as an operating surgeon or at one of the dressing or ambulance stations, in which case his place will be taken by the medical officer next in rank) will remain in touch with his regiment and supervise the first-aid work of the hospital corps. The regimental medical officers and men of the hospital corps will be distributed along the line as near the front as possible. It will be their duty to render first aid to all whom they are able to reach, to prevent loss of life in particular cases, such as severe hemorrhages, to prevent malingering and crowding at the dressing stations, and to have general supervision of the bearers in advance of these stations. If required, the members of the regimental band and a detail of men from each company will be utilized as litter-bearers. The wounded should be placed under cover from fire if possible, and those able to walk may go to the rear, but bearer assistance at the front can usually not be given until after the engagement is over or an advance has been made. The rapidity of fire, long range, and flat trajectory of the modern rifle are such that surgical assistance on the firing-line is now seldom possible. The regimental medical officers and hospital corps men can therefore carry on their work at the immediate front only to a limited extent. They should take advantage of every lull in firing, but a litter with bearers offers such a large target that at the immediate front a wounded man lying on the ground has greater chance of escape than one raised for transportation. Wounded men will, therefore, often be left unaided or only with such assistance as their comrades can offer, and this emphasizes the necessity that all members of the fighting force be instructed in the elementary principles of first aid and the use of the first-aid packet. Assistance given on the firing-line will usually, therefore, necessarily be confined to check-

ing hemorrhages, applying first-aid dressings, and immobilizing fractured limbs. The regimental medical officers should attach diagnosis tags to the wounded so far as possible, indicating whether the wounded man may be carried or is able to walk, and, if the case is urgent, an "urgent tag" is also attached.

Next behind the regimental aid are the *dressing stations*, designated during the day by red-cross flags and at night by red lanterns. These are especially under the direction of the brigade surgeon, using the dressing station equipment of the ambulance company and the necessary personnel therefrom. They should be located at points in the rear of the line of battle where the wounded will be sheltered from fire, and as near as possible to roads leading to the rear or in proximity to open country over which the ambulances may be driven. In engagements behind fortifications these dressing stations may be at the immediate front behind the breastworks. The personnel of the dressing station will consist of two medical officers of the ambulance company, thirty bearers, and a designated number of non-commissioned officers. The station having been located, the ground should be cleared and the equipment placed to the best possible advantage. Litter squads should be at once sent out to bring in the wounded from the front, these being given particular instructions to take advantage of cover as much as possible, in order to give themselves and the wounded they may be carrying all possible protection. The character of the surgical work done at the dressing station will be usually only of an emergency nature, such as arresting hemorrhage, immobilizing fractures, and administering stimulants to relieve shock. If first-aid dressings have been already applied and no hemorrhage is present, it is best to leave these cases undisturbed until they reach the field hospitals. Where the wound is exposed and the conditions permit, it may be thoroughly cleansed with boiled water and a dressing applied, but, if the press of work is great, it should be simply packed or covered with a sterile dressing and the wounded person sent to the rear.

The *ambulance stations*, usually one to each brigade, will be established by the brigade surgeon at suitable places which afford protection from fire. When the topographic features of the battlefield allow, the dressing stations and ambulance stations may be consolidated, thus doing away with an intermediate halt and transfer of the wounded. In other cases the ambulance station will be placed at a suitable distance behind the dressing station, or separate ambulance stations will be established at more than one point in rear of the brigade, the endeavor being to shorten as much as possible the distance which the wounded have to travel from the dressing station to the ambulance station. If there be but one dressing station, it will be in charge of the senior medical officer of the ambulance company. If more than one is established, junior officers will be given charge, and a suitable number of enlisted men assigned to each. As soon as the ambulance station is established, the cook should start a fire and prepare hot liquid foods. The medical officers receive the wounded from the dressing station, attend to those not already dressed, attach diagnosis tags to those not already marked, and, as rapidly as possible, transfer

the wounded who are unable to walk by ambulance to the field hospital. Should a change be made in the line of battle, a corresponding change in the position of the dressing and ambulance stations will be effected whenever possible. If the line of battle advances, a suitable number of ambulances will follow up the advancing line, leaving others to clear the field before participating in the forward movement. In case of backward movement of the firing-line, the dressing and ambulance stations will be shifted to the rear, and, if the field hospital is endangered, the chief surgeon will determine its movements. When it is impossible to move the field hospital or the wounded have to be left in buildings utilized for hospital purposes, the red-cross flag, under the terms of the Geneva Convention, will protect places so designated as much as may be from fire.

While in any general action the dressing and ambulance stations in the rear of the troops actively engaged will be more or less employed in the care of the wounded, the principal work of the ambulances will begin at the end of the battle, when the whole field may be searched and the wounded cared for.

The *field hospitals* required during a battle will be established by the division surgeon after consultation with the division commander. They should be located at least three miles from the front, near a practicable road, and on a stream or where there is abundant water whenever feasible. It is desirable also that the hospital should be located near buildings which may be utilized for hospital purposes. To avoid confusion, the field hospital should be divided into the receiving section, the dressing section, the operating section, and the wards. When the wounded are brought in, the medical officer in charge of the receiving section should examine each case and send it either to the dressing section, the operating section or the wards, as may be required. In this way much confusion will be prevented and the wounded can be more quickly and properly cared for. The commanding officer of the hospital will exercise general supervision and will see that suitable medical officers, non-commissioned officers, and attendants are detailed to each section of the hospital. The experience of recent wars has demonstrated that the operating section does not now require to be nearly as large as before the days of conservative treatment. It is now the rule to operate only in such cases as imperatively demand such procedure. Antiseptic or aseptic treatment, antiseptic or aseptic dressing, protection and immobilization are most practised, and the patients are then transferred as quickly as possible to the well equipped hospitals at the base, where, if operation is demanded, it may be carried out under all the requirements of modern aseptic technic. The work in the field hospital should be directed toward completing all operations imperatively called for as quickly as possible and toward preparing the wounded for transportation to the rear, for, if an advance or retreat follows the battle, the hospital should be ready to meet such condition. If the troops advance, the hospital should be cleared as much as possible of the wounded, or they should be cared for in adjacent buildings, and the hospital, or as much of it as is not imperatively required to shelter the wounded left behind, should follow the troops unless the distance which

the troops move forward is short. In case of retreat, if possible the hospital should be moved with the wounded to the rear. When this is impracticable, the wounded, as in case of a forward movement, should be left as well protected as possible and with the red-cross flags displayed to insure the protection afforded by the Geneva Convention.

The difficulties in establishing the aid stations and field hospitals for use in battle at places where they will be most useful and suitably protected are many, and efficiency in such cases will depend largely upon the understanding by the medical officers of the special duties which each will be required to perform. The bringing forward of the ambulance companies with their ambulances and the moving of the field hospital train, encumbered as the roads often are with long wagon trains, troops, and ammunition trains pressing to the front and with reserves coming up, present difficulties which are often almost insurmountable and require a high degree of executive ability on the part of the senior medical officers. In such circumstances clearness of judgment, prompt decision, and resourcefulness are necessary to the highest efficiency. To these qualities must be added a thorough knowledge on the part of the medical officers of the technical details of the disposal of personnel and equipment, and only by the combination of all these factors can the wounded be cared for with economy of time and labor and as promptly and properly as the conditions incident to the action permit.

THE TREATMENT OF WOUNDS IN WAR.

Having discussed the general duties of the military surgeon at the front in time of war, we have now to take up the surgical work which he is required to do.

In considering wounds received in war, their treatment, and the effects both immediate and remote of these traumas, two factors present themselves which have particular bearing upon military surgery proper: first, that the wounds received in war are made by instruments specially designed to kill or produce disability; second, the wounds so made have to be treated under conditions in general materially different from those which obtain in surgical practice in civil life in time of peace. The great majority of wounds received in war are made by rifle bullets or other penetrating missiles. The trauma is usually mainly subcutaneous, therefore hidden from view, and the character of the tissue destruction cannot be determined by inspection, but can be known to the surgeon only through study or previous experience with like cases. The insignificant wound of entrance of the modern small-caliber rifle bullet gives no evidence of the amount or character of tissue destruction which it may have produced. With such insignificant external wound, the soft parts beneath the skin may be extensively lacerated, or, if a bone is struck, it may be extensively comminuted or pulverized, and the brain or other solid organs of the body, if struck, may be partially or almost completely disrupted. Even wounds from hand weapons depend for their gravity most generally upon the amount of subcutaneous destruction or deep infection which is present.

The conditions relative to treatment which surround both the surgeon and the patient in war are peculiar and special. The wounded often do not receive treatment until a considerable period of time has elapsed after receiving the injury. They then frequently have to be roughly dressed and transported often over rough roads for a considerable distance before they can reach even the field hospital, where more special attention can be paid them. Here the conditions, while better than at the immediate front, are far from being the almost ideal ones which now obtain in civil hospitals. The shelter afforded is that of tents or ordinary buildings, the number of wounded is large in proportion to the number of attendants, the press of work is great, the appliances are often limited, and the general conditions do not favor the careful and systematic exploration and care of wounds which usually obtains in civil life. In military practice after battle the number of wounded is great and the attendance small; in civil life the opposite condition obtains—the number of injured by accident is small, while the number of the attendants is large. The question of transportation is also an important one. A wounded man, instead of being kept quietly in a well-provided hospital, is transported from the front to the field hospital, and then by train, boat, or other conveyance to the base hospitals at the rear. From there he is frequently transported still farther back to general hospitals, or even civil hospitals when such are used. The wounded man, therefore, instead of being systematically watched and tended by a given surgeon or surgeons, is shipped from one point of assistance to another, with constantly changing personnel for his treatment. It therefore follows that while the science of surgery—that is, the general rules which govern tissue-trauma, the pathologic processes which result, and the means by which the surgeon may favor nature's methods of repair—is the same for all surgery, whether military or civil, the art of surgery—that is, the application of the surgeon's knowledge to the conditions present—necessarily varies according to the conditions surrounding the case. The practice of military surgery is, therefore, somewhat different from that of the surgery of peace.

As the peculiar nature of the traumas received in war requires thorough knowledge on the part of the surgeon in order to enable him suitably to treat them, all authorities on military surgery are unanimous in the opinion that the surgeon treating these cases should be familiar with the implements by which the injuries are inflicted, otherwise he cannot properly understand the character of the traumas or suitably care for them.

War Weapons.—Weapons used in war are divided into two main classes: (*a*) hand weapons, (*b*) firearms.

Hand Weapons.—Under the term hand weapons are included all weapons wielded by hand other than those in which an explosive powder or expanding gas is used. The term *edged weapons*, or *side arms*, is used by some writers, but these terms are too restricted, in that some of the hand weapons depend for their efficiency not upon a cutting-edge but upon a point, and the term side arms is still more restricted, in that it refers particularly to the hand weapons carried by an officer or soldier and does not include such weapons as the spear, the arrow, etc. Of hand

weapons there are three main classes—the striking, the thrusting, and the cutting weapons. The typical striking weapons are the hammer and the mace, now obsolete, but the butt of the rifle or pistol at close quarters is occasionally used as a weapon of this kind; while of the thrusting instruments the straight sword, the bayonet, the spear, and the dagger are typical examples, in that in these instruments the point is mainly used, although, if the bayonet be broad-bladed or the dagger be like that of the Malay kris, the edges of these weapons affect the size and character of the wound. The saber is the typical cutting instrument with which part of the troops of modern armies are provided. The Afghan knife, the Cuban machete, and the Filipino bolo come under the same class. Many of the broad-bladed Asiatic swords wielded by one or two hands, and depending upon their edge and not upon the point for their efficiency, are also included.

Wounds by Hand Weapons.—The number of wounds by hand weapons in relation to the total number of wounds in war is comparatively small. In the American Civil War it was .37 of 1 per cent. In the Franco-German War, 1.3 per cent. Information from the war between Russia and Japan indicates that, while the total number of wounds by hand weapons was not large, the number was considerable in some organizations. The high efficiency of the modern rifle and artillery fire gave rise to the development of the night attack, in which the attacking force, without firing a shot, creep up to the intrenchments of the enemy and then precipitate themselves against the foe, using their hand weapons in the close hand-to-hand mêlée which follows. Troops engaged in such attacks had a large percentage of wounded by this class of weapons, but the total in the army was comparatively small. Similar conditions in future wars will undoubtedly give rise, in troops so engaged, to quite a large number of wounds from weapons of this kind.

Wounds made by *striking weapons* are few in number, and when seen present no special characteristic. A wound by the butt of a musket may be simply a superficial or a subcutaneous contusion, or a fracture of a bone, and, if the head be struck, the wound may be accompanied by concussion or compression of the brain. Such wounds are so like the ordinary wounds by violence seen in civil life that they require no special comment.

Wounds by Cutting Weapons.—Wounds by these weapons have an incised quality for their main characteristic, although, if the weapon be dulled, as is the case with the saber, the wound is also somewhat lacerated, the tissues being torn apart as well as incised. With the sharp-edged Asiatic swords, and with the machete or bolo, deep, cleanly cut wounds may be made. Large areas of superficial tissue may be sliced off, the skull may be cleft, or an upper extremity may be partially or completely severed. The main peculiarities of these injuries are that the hemorrhage is generally profuse, the artery being cleanly cut; the wound is generally, though not always, infected; is wide open; and muscles, tendons, and nerves are frequently severed, with resulting disability. If a large vessel is wounded, the hemorrhage is usually profuse and severe, requiring immediate treatment either by compression or ligation. In many cases

the artery can be ligated directly in the wound, the clean-cut, wide open wound particularly favoring this operation. If tendons or nerves are severed, they should be united at the earliest possible time. Too frequently the surgeon neglects to do this, and operation after healing of the wound and when a cicatrix is formed makes uniting of the retracted structure much more difficult, and, if some time has elapsed, degeneration of the nerve may prevent restoration of its function.

In most cases the subcutaneous tissues and skin may be immediately approximated by sutures; but in all cases it is best to leave a small drain at the most dependent part, complete closure of the wound being contra-indicated because the presence or absence of infection cannot always be accurately determined, and a small drain will do no harm and may do much good by preventing the serious results which may follow in a closed wound if infection be present.

Wounds by Thrusting Instruments.—Wounds by thrusting instruments generally unite the characteristics of laceration and incision, the incised quality being particularly prominent in wounds made by the sharp-edged Asiatic sabers and by such weapons as the Malay kris. Their gravity depends upon the character of the subcutaneous injury and the frequently deeply placed infection. Blood-vessels, nerves, and tendons may be severed, or deeply seated organs or vessels wounded. As in bullet traumas, the skin-wound gives no indication of the amount or character of subcutaneous injury; while the fact that infection may be carried deeply into the tissues, so leading to deep inflammation or suppuration, with resulting deep abscesses or purulent infiltration along muscle sheaths or other paths of least resistance, gives these wounds their peculiar character and danger. In some cases the wounds are uninfected, but any wound made by hand weapons should always be looked upon with suspicion in this regard.

The treatment of wounds of this character must necessarily depend largely upon the evidences of subcutaneous injury which are present, but, unless it is known to be trifling in character, it is generally best carefully to expose it under aseptic technic, if necessary enlarging the wound of entrance to insure careful and thorough exploration, cleaning, and drainage. In most cases also it is advisable to insert at least a temporary drain down to the extreme bottom of the wound.

Fractures of the Skull by Hand Weapons.—Fractures of the skull by hand weapons, if the cranial cavity is opened, are always grave. When the wound is made by a cutting weapon, even though the skull be quite cleanly incised, the meninges of the brain are liable to be wounded and small spiculæ of bone or detached plates of bone from the inner table are very frequently driven into the brain. When the fracture is made by such weapon as a bayonet, the probability of the presence of indriven bone fragments is increased, and from the rather blunt-ended weapon being driven through the skull and the overlying scalp the probability of infection of the intracranial structures is great. Wounds of this character are particularly dangerous on account of this fact, local or general meningitis very commonly developing.

The treatment of wounds of the skull by hand weapons is directed first to the arresting of hemorrhage if it be present; second, to removal of all indriven or displaced bone fragments; and, third, to the thorough cleansing and drainage of wounds in order to prevent intracranial inflammation. Every fracture of the skull made by hand weapons should be thoroughly and carefully explored, and, if both tables have been broken, a trephine or other opening should be made in the skull so that the intracranial condition may be determined. In doing this work great care should be taken not to produce additional injury to the dura mater, for loss of any part of that membrane is apt to be followed by hernia cerebri. Removal of all depressed and displaced fragments and a careful stitching of the dura, with the exception of a small opening through which a small wick-drain is inserted, may usually be practised. If there is much loss of dura, its place may be supplied by a piece of the pericranial aponeusosis which can be obtained by lifting a flap of scalp. Such treatment will greatly lessen the probability of general meningeal inflammation when infection is present. Where the wound is clean, the drain may be removed at the end of forty-eight hours with little fear of bad after-effects.

Penetrating wounds of the chest by hand weapons owe their gravity usually either to the hemorrhage which may immediately result or to the inflammation which may follow infection. The treatment of these cases is much the same as treatment of like wounds of the cranial cavity, except that it is possible to practise a greater degree of conservatism unless it is seen that the wound is manifestly infected or dangerous hemorrhage is present; the treatment then becomes similar to that adopted for bullet wounds of the same region, and will be discussed later.

Penetrating wounds of the abdomen by hand weapons are of great gravity. The fact that hand-weapon wounds are so frequently infected makes it probable that general peritonitis will follow even though visceral injury is not present. The treatment of these wounds, as with penetrating bullet wounds of the abdomen, must depend entirely upon the conditions which are present. If injury is present, it should be repaired, and in all cases it is probably advisable to carry a small gauze drain out through the original weapon-wound. Under other conditions, viz., those which ordinarily obtain at the front in time of war, operative interference, as with penetrating bullet wounds of the abdomen, is contraindicated except in those cases where the danger is greater to the patient from non-interference than from the infection which may follow operation under septic conditions.

Wounds by Miscellaneous Destructives.—Miscellaneous destructives used in war depend for their effect upon explosives. Torpedoes, fougasses, mines, and hand grenades are the principal destructives of this class. The injuries from these are of widely varied character. If the wound is made by fragments of a torpedo, a fougasse, or a hand grenade, it will resemble the wounds made by shell fragments. If made by the rending force of the explosive, it will usually be ragged in character, and, if the injured person is near the source of explosion, an extremity may be blown off or the body itself extensively lacerated. In mine

explosions the person injured may be crushed under falling timbers, earth, or rock, or may be struck by any of these, producing more or less extensive destruction of the soft parts, fracture or comminution of the bones, or rupture of internal organs. This class of injuries is to be treated according to the general principles of surgery, and therefore requires no specially detailed discussion here.

Firearms and Wounds Made by Them.—Under firearms are classed all weapons from which projectiles are propelled by means of exploding powder or expanding gases. The wounds from such weapons are known as *gunshot wounds*, the term being applied to any traumatism produced by a missile set in motion either directly or indirectly by the force of the exploding powder or expanding gas. A missile propelled directly from the source of powder and producing a wound is known as a *direct missile*, whether it be the regular projectile from the piece or a part of the piece itself in case of explosion of the firearm. An *indirect missile* is a missile set in motion by a direct missile. Wounds by indirect missiles are not uncommon; coins in the soldier's pocket or pieces of his accouterment may be driven into his body by a bullet, fragment of a shell, or other direct missile.

Firearms are divided into two main classes—small arms and artillery. Under small arms are classed all firearms carried by the soldier and having no support of their own, such as the rifle, pistol, etc. Shotguns, muskets, and multiple firing arms, such as the revolver, are included in the same class. Under artillery are classed all firearms having support of their own, whether the pieces of ordnance are movable, as in the case of the field artillery mounted on wheels, or fixed, as in the case of the coast defense guns.

On account of the wide difference in size of the different kinds of firearms the projectiles for them differ greatly in size, shape, and weight, and consequently in the traumas they may produce.

Artillery Projectiles and Wounds by Them.—The projectiles used by artillery are mainly of four kinds—solid-shot, shell, shrapnel, and canister. Solid-shot and shell are primarily used as defense destroyers to batter down earthworks, pierce the armored sides of vessels, etc. When they produce a traumatism, the character of the wound will depend upon whether it is made by an unbroken missile or a fragment of it.

Wounds by unbroken artillery projectiles are among the most serious seen in war. These projectiles are so large that the wounds are always serious; large parts of the body may be torn away or an extremity amputated. Their crushing and lacerating effect is such that the wounds made by them resemble the large traumas caused in railroad accidents. The soft parts are lacerated and pulpified and the bones crushed and splintered. Hemorrhage is ordinarily profuse when the large vessels are involved; but, from the lacerated character of the wounds, the hemorrhage, unless the larger vessels are wounded, is usually checked by contraction of the lacerated vessel walls. Shock is usually pronounced, especially if the wound be large, the body struck, or an extremity amputated.

The treatment of wounds made by unbroken artillery projectiles is

usually operative; that is, if an extremity be struck and partially or completely amputated, amputation has to be done above the wound, care being taken in performing the operation to insure sound flaps, as the tissues are frequently crushed and devitalized for some little distance from the wound. Where amputation is not done or is impracticable, as in body injuries, all ragged tissue should be trimmed away, the wounds approximated as much as possible, as much of the skin saved as may be, and, when granulation has progressed, skin grafting done if necessary.

Wounds by Shell Fragments.—While wounds by solid-shot are comparatively infrequent, those by shell fragments are much more common. Wounds by shell fragments differ greatly in size and character, as the amount of tissue destruction, the depth of the wound, the danger to life, and the after-effects of the injury depend largely upon the size, weight, and velocity of the fragment by which the wound is made. When wounds are made by large fragments, they resemble the wounds made by solid-shot, in that large portions of the body may be torn away or an extremity amputated. From these large and extensive traumas, shell wounds range through all grades of size and amount of tissue destruction down to the minute injuries made by exceedingly small fragments. The modern high explosives with which shells are charged tend to break these projectiles into many fragments, often as many as two or three thousand in number. For this reason multiple wounds by shells are now common. Suzuki and other observers in the Russo-Japanese War record cases in which there were as high as one hundred wounds or more in a single individual. The larger wounds are almost invariably infected, the size of the fragments and their irregular shape greatly increasing their proneness to carry pieces of dirt and clothing into the wounds, and the size of the wounds is particularly favorable to secondary infection. The wounds by very small fragments may in certain instances be sterile, but in all cases there is much greater probability of infection in shell wounds than in bullet wounds. In all shell-wounds tissue-laceration is present, and, if the bones are involved, these are usually extensively comminuted, the amount of comminution depending upon the size of the shell-fragment, its velocity, and its angle of impact against the bone. High velocity and direct impact tend to produce the greatest amount of comminution, while slow-moving fragments or oblique impact may produce only oblique or transverse fractures.

The general treatment of a wound by a shell-fragment is that of a lacerated and infected wound. At the first lines of assistance during battle these wounds should ordinarily be simply protected by first-aid dressings, the dressing for shell-wounds now in use in the army and navy being particularly well adapted for this purpose. If the wound is of an extremity and the amount of destruction in the soft parts is considerable, even though the bone be not broken, the limb should be supported by splints or by binding it to the opposite limb, if it be a lower extremity, or to the body of the patient if it be an arm or forearm. At the field hospital, if the wound is large and open, it should be carefully explored and all ragged tissue removed. The wound should be covered as much as pos-

sible by skin in order to expedite healing, and should thereafter be treated by cleanliness, irrigation, antiseptic dressings, and drainage. If the main blood-vessels of an extremity are destroyed or the wound be so large or so greatly infected as to endanger life, amputation may be required. The smaller wounds may be treated expectantly unless there are evident signs of infection or inflammation. Should inflammatory symptoms appear or suppuration continue, the wound should be immediately and thoroughly explored. Persistent suppuration in a shell-wound usually indicates lodgment of infected material, such as a piece of clothing, at the bottom of the wound, and when the offending material is removed the wound usually heals promptly.

Shell-wounds of the body cavities are always of great gravity, in that the opening is usually large, ragged, and from the size and character of the missile the wound is apt to be infected and the contents of the body cavity considerably injured. All shell-wounds of the head should be very carefully explored, and, if fracture of the skull is present, the skull should be trephined or otherwise opened unless there is entire absence of all symptoms of intracranial injury. In penetrating shell-wounds of the abdomen the surgeon is confronted with the same difficulties as in the case of penetrating wounds of the same region by bullets or hand weapons. Should conditions permit, which will rarely be the case in war, the abdomen should be opened in the median line in every case of penetrating wound, the visceral lesion, if any, repaired, and a drain carried out through the original wound.

Wounds by Shrapnel.—Shrapnel produces the largest number of wounds by artillery missiles seen in field engagements. A shrapnel consists of a cylindro-conoidal case partially filled with bullets and containing an explosive by which the case is disrupted and the bullets scattered. The bullets are of lead, round in form. The wounds by shrapnel are therefore of two kinds, those produced by fragments of the case and those produced by the bullets. The wounds by fragments of the case are identical with those made by fragments of shell. The wounds made by the bullets are similar to the bullet wounds made by the bullets of low velocity from the older firearms, and are therefore usually not so serious as those made by the modern small-caliber rifle bullets. They do not usually penetrate deeply, are more apt to slide around tendons and blood-vessels without injuring them, and are more readily deflected from their course by bones or even the more resistant structures of the soft parts. A shrapnel bullet may strike a rib, be deflected by it, and make a contour wound about the chest wall, while a modern small-caliber rifle bullet is rarely, if ever, so deflected, but plunges directly through, cutting everything in its course. The fractures made by shrapnel bullets are rarely extensively comminuted, but resemble those made by a comparatively slow-moving agent.

Infection is frequently absent in wounds made by shrapnel bullets, this being especially true of the wounds made in summer, when the men are lightly clad and have fairly clean clothing. In winter, with heavy clothing which is more or less soiled, infection is much more common, but usually a shrapnel bullet wound can be considered uninfected unless it is

evident that foreign material has been carried into the wound or inflammatory symptoms have appeared. The treatment of wounds by shrapnel bullets does not differ in any particular from that of wounds by other bullets, and will be considered under the general heading of bullet wounds.

Canister produces wounds similar in almost every particular to those produced by shrapnel. A canister shot consists of a cylindric outer iron casing containing a large number of round lead bullets, but no explosive. It is used only for short-range work. The case is fractured by the explosion within the piece, the bullets and fragments of the case then being scattered widely to the front.

Small Arms and Wounds by Them.—The small arm which produces the greatest number of wounds in war is the military rifle. Approximately 90 per cent. of all wounds in war are by the projectile from this arm. The piece itself is the result of the gradual evolution of firearms caused by endeavors to increase the range of the piece, its rapidity of fire,

FIG. 501.—EVOLUTION OF THE RIFLE BULLET.
From specimens in the Army Medical Museum. *a*, Musket ball; *b*, Minié-ball; *c*, Springfield, caliber 45; *d*, brass-jacketed Remington; *e*, Mauser.

and to flatten the trajectory of its bullet. The modern military rifles and the projectiles fired from them are practically the same among the modern civilized nations. The rifle used in the United States army weighs a little under 9 pounds, is 43.5 inches long, has a barrel 24 inches long, its bore has a diameter of 0.30 inch, and the twist of the rifling is one turn in 10 inches. The powder pressure in the chamber at the time of discharge is about 49,000 pounds to the square inch. The gun is of the magazine type, and its rapidity of fire is such that twenty-three aimed shots have been fired in one minute with it when used as a single loader and twenty-five shots in the same time when using magazine fire.

The bullet is an elongated missile with an ogival head. It is 30-caliber,—*i. e.*, 0.30 of an inch in diameter,—is 1¼ inches long, weighs 220 grains, and consists of a core of lead and tin composition inclosed in a jacket of copper and nickel. To propel this missile about 44 grains of nitroglycerin powder are used. The velocity of the missile when it leaves the rifle is 2300 feet per second, and, as the twist of the rifling is one turn in

10 inches, the bullet revolves upon its long axis about twenty-five hundred times per second. On account of its great resistance to deforming violence, due to its outer jacket of cupro-nickel, its high velocity, and its small size, this missile has great penetrating power. At 50 feet it will penetrate 54.5 inches of pine, and at 1000 yards it will still penetrate 13.2 inches of the same material.

As the high velocity of this missile is an important feature in the form of trauma which it produces in the human body, some conception of its velocity should be had. The initial velocity of a missile is its velocity at the time it leaves the piece; its remaining velocity is its velocity at any given point in its flight before it comes to rest. The military surgeon is concerned only with the remaining velocity, that is, with the velocity of the missile at the time it produces the injury. But the velocity of this particular missile is so great in relation to its size and weight that, so far as the human body is concerned, the missile is almost always driven straight ahead through the tissues, and is rarely deflected by any of the structures, not even by the densest bone. While the missile itself is small, from its high velocity it is capable of striking the resistant tissues, such as the bone, with great energy; and its velocity, together with its small size and ogival head, causes it to penetrate much more deeply than the older, larger, and more slowly moving missiles. The possibility of deep infection and injury to the deeper structures, blood-vessels, nerves, and viscera is thereby increased, and this accounts for the serious injury which the missile may produce although it is small in size.

The *results following the use of the modern military rifle in war* come under three heads: (*a*) its effect in producing death upon the battlefield; (*b*) its early effect upon the wounded who come under treatment and recover; and (*c*) its late effect upon the wounded who recover.

Of these, the first, viz., its effect in producing death upon the battlefield, is of the greatest interest to the military expert; and, in this connection, it may be said that previous to the experience of recent wars the immediate death-dealing capacity of the modern military rifle was much underestimated by many writers. It was, and is still, thought by many that the small size of the bullet would much lessen the probability of its producing immediate death; but in this supposition the element of greater penetration is overlooked, and the real results seem to show that the number of those killed outright upon the battlefield is as great as, if not greater than, in former wars where the larger and more slowly moving bullets were used. Thus, in the Crimean War, among the English troops there was one killed to every 4.39 wounded, this being the highest proportion of killed to wounded recorded previous to the Anglo-Boer War. In the American Civil War the proportion was one killed to 5.57 wounded, and in the Franco-Prussian War one to 5.77. Comparing these data with the ratio killed to wounded in recent wars, we find that the lowest proportion was in the Spanish-American War in Cuba, where there was but one killed to 6.28 wounded; but in the Philippine War one was killed to 5.33 wounded, and in the Anglo-Boer War one was killed to 4.12 wounded, a higher proportion than in any preceding war. The complete statistics

of the Russo-Japanese War are not yet obtainable, but from the figures given out it appears that the ratio of killed to wounded has been fully sustained by the modern rifle.

As to the second effect of the use of the modern rifle, viz., its more immediate effect upon the wounded who recover, it may be stated that, as the use of the new arm and modern surgical methods came practically together, it is extremely difficult to determine the exact effect which each of these has had relative to the outcome in the case of the wounded who recover. That each has had a definite effect cannot be doubted, for, by comparing the mortality in flesh wounds in recent wars with that in former wars, it is seen that the percentage of death from such wounds is extremely small, proving that by modern aseptic and antiseptic methods deaths are now prevented which formerly occurred from septic or inflammatory conditions. Equally, it appears that in the large majority of the wounded who come under treatment the small size of the missile has materially lessened the amount of tissue destruction, except in those special cases where the high velocity and deeper penetration of the missile have caused serious wounds of body cavities or contained viscera. It appears, therefore, so far as the wounded who come under treatment are concerned, that, considering the total number, the number of recoveries in this class has greatly increased, and also that rapid recoveries are more common than formerly. At the same time, from its high velocity and great penetrating power, the missile, when it penetrates the body cavities, can there produce such serious injury that in wounds of these regions the mortality is still quite high. However, the two factors of decreased size of missile and modern surgical methods have, in the total, materially decreased the mortality of wounded; for, while among the English troops in the Crimea 15.2 per cent. of the wounded died, in the American Civil War 12.9 per cent., in the Franco-German War among the Prussian troops 11 per cent., in the Spanish-American War but 5.3 per cent. died, and in the Anglo-Boer War but 8.3 per cent. The available statistics of the Japanese troops in the Russian War give a low mortality of wounded, but the exact figures covering all deaths among the wounded have not yet been published. In summary, it may be stated that the wounds produced by the modern rifle bullet are either almost immediately fatal or of such a character as to make the probability of recovery very great, except in the case of wounds where vital organs are struck.

As to the third result, viz., the late effect upon the wounded who recover, it appears that permanent disability is much less apt to occur than was the case when larger missiles and the older surgical methods were used. A greater proportion of the wounded recover quickly and return to the fighting force. This has been noted by all observers in recent wars, so much so that it may be questioned whether a military arm which kills a large proportion immediately upon the battlefield and disables another large proportion only slightly and for a brief period of time, so allowing their quick return to the front, is a particularly effective military weapon.

The Character of the Traumas Produced by the Modern Military

Rifle Bullet.—The character of the traumas produced by this missile depends largely upon two factors: (*a*) the velocity of the missile at the time of impact, and (*b*) the structure of the tissue or part wounded.

The interrelation of these factors appears to determine quite definitely the character of the tissue destruction, the greatest being produced when a bullet at maximum velocity strikes the more resistant structures, such as compact bone or fluid-saturated organs. This might be expected, for the dynamics of a bullet are similar to those of any body in motion; the energy given out by any moving body when partially or wholly arrested depending upon the velocity of the moving body and the amount of resistance which it encounters. If a moving body encounters but little resistance, it gives out but little of its energy; but if it encounters great resistance, the energy given out at the place of resistance is great. Certain tissues of the body, such as the skin, muscle, fascia, and adipose tissue, offer but little resistance to the small, ogival-headed rifle bullet; it therefore expends in them only sufficient energy to penetrate them, and consequently it penetrates such tissues cleanly and directly, cutting quite smoothly whatever lies in its path. Even the spongy bones, as those of the face, carpus, metacarpus, epiphyses of the long bones in old persons, or bone softened by disease, are generally perforated cleanly or with little shattering, whatever the range or velocity of the missile may be.

When, on the other hand, the missile is resisted, just so much as it is resisted will it transmit its energy to the tissues struck. It is this factor of resistance which explains the destruction done by a deformed missile at high velocity when it strikes the body; for the deformed missile offers a larger striking surface, thus causing the tissues to resist its passage, and transmitting to them on account of the resistance which it encounters a greater amount of its energy, the transmission of energy being evidenced by the greatly increased size of the trauma.

It follows that the rifle bullet, whether deformed or undeformed, produces its minimum amount of traumatism at long range, *i. e.*, when at low velocity, and that when the tissues struck are resistant, the amount of tissue destruction increases with the shortness of the range and the consequent higher velocity of the missile. At long range the undeformed bullet produces a minimum amount of comminution in the shafts of the long bones or bones composed of compact tissue, and the minimum amount of destruction in organs with fluid contents (stomach, intestines, and bladder) and bodies of spongy texture containing large quantities of fluid (brain, liver, spleen, and kidneys). But in these tissues and organs the destructive effect of the bullet increases with the shortness of the range, until at about six hundred yards and under it will produce extensive comminution in compact osseous tissue and will often act with explosive violence upon the brain, liver, kidneys, spleen, or stomach, unless the last is empty.

If the bullet, instead of being smooth-headed, is deformed, the amount of destruction which it produces with given velocity and resistance of tissue will be in proportion to the size of its striking face. The more deformed the missile, the greater the destruction it will produce.

The explosive effect of the small-caliber bullet has been noted by all writers, and various theories have been advanced as to its cause. It appears, however, that this effect is simply as indicated above, viz., the transmission of the great energy of a high-velocity missile to the tissues. The explosive effect is seen only in the resistant tissues, that is, tissues which from their structure are hard or are filled with incompressible fluid. When the bullet impinges upon organs or tissues which present but little resistance to its course, it makes clean-cut perforations of them, immediately fatal results arising only from wounds of blood-vessels, perforations of the heart, or impingement of the bullet upon some vital part of the central nervous system. Lateral transmission of energy is the factor of main importance in producing explosive effect. It seems most probable that this energy is transmitted in either of two ways: through the transmission of

FIG. 502.—DEFORMED BULLETS REMOVED FROM SPANISH-AMERICAN WAR CASES.
A, Shrapnel; B, brass-jacketed Remington; C, Mauser bullets.

vibrations set up in compact bone tissue by the impact of the bullet or by the sudden displacement outward of the molecules of incompressible fluid in fluid-saturated or fluid-containing organs. Compact bone, when struck by a missile at high velocity, is disrupted by the suddenness of the shock, and not only are vibrations set up in the bone, but the osseous particles are driven outward and act as secondary missiles which increase the trauma either by directly destroying the tissues or by transmitting the energy of the missile to them. When a fluid-containing or fluid-saturated organ is struck by a high-velocity missile, the impact is so sudden and violent upon the incompressible fluid that the energy is transmitted in all directions by the molecules of the fluid, and wide disruption of the organ occurs. With a bullet moving at lower velocity, the shock in the bone or organ is less, the disruption consequently less, and with still lower velocity the ball may pass through the same tissue or organ with prac-

tically no lateral destructive effect. This explains why in some cases the skull and the contained brain are greatly injured, while in other cases the same structures are simply perforated; the first effect being due to a high-velocity and the second to a low-velocity missile. The result may be likened in a way to the difference in effect produced by dropping a bullet into water contained in an open vessel and by firing a bullet into it; in the first case the bullet will enter the water making only a slight disturbance, and that mainly upon the surface, while if the bullet be fired into the water, the vessel, even though open at the top, will be completely destroyed and the water thrown to a great distance in all directions.

Effect of the Compound Bullet on the Skin.—As the skin is elastic and comparatively non-resistant, the wounds made by the undeformed rifle bullet correspond closely to the size of the missile itself. Unless the bullet strikes a bone in its passage through the part, the exit wound is usually but little larger than the wound of entrance, and closely resembles it in appearance. When the bullet strikes perpendicularly to the skin surface, the wound is usually circular in shape, about one-third of an inch in diameter, slightly depressed, and soon covered with a black scab from the coagulated blood. When the bullet enters obliquely, the wound of entrance is generally oval in outline, and, when the missile enters or passes out through a fold in the skin, the wound may be slit-like and so small in size as to be difficult to find. After a few days the edges of the wound may present a slight superficial necrosis or inflammation, but, if the tissues be not infected and the wound is kept protected, it usually heals within a week or ten days without suppuration. With deformed missiles the entrance wound is usually much more jagged in outline, and where the deformed missile passes through the part after producing an explosive effect, the exit wound is considerably larger than the wound of entrance, is ragged in outline, and because of its size is much more liable to secondary infection. The same may be said of an exit wound when an undeformed missile strikes resistant bone at high velocity, so producing an increased amount of trauma and driving particles of bone out through the wound of exit.

Shrapnel bullet wounds of the skin differ but little from rifle bullet wounds in size or other characteristics; in fact, it is generally impossible to tell from the appearance of the wound whether it has been made by rifle or shrapnel bullet.

Connective tissue, adipose tissue, and muscle, from their loose and open structure and from their not being fluid-saturated, transmit lateral impulses but feebly, and the injury to these tissues is therefore confined to the track of the bullet, unless they are in the path of destruction produced by a deformed missile or an undeformed missile giving explosive effect.

Tendons.—The modern rifle bullet is but rarely deflected from its course by tendons, and injuries to these structures are much more common than was the case when the slower moving bullets were used. These latter projectiles were readily deflected by resistant structures, which now frequently escape when impinged upon by a shrapnel bullet.

The action of the modern rifle bullet is more knife-like and direct, and the surgeon should suspect solution of continuity whenever a tendon lies in the track of a bullet. When a tendon is severed, it should be united as soon after the injury as possible; otherwise the retraction of the muscles and the binding of the tissues together by the resulting cicatrix make the union of the tendon more difficult and the restoration of function less probable.

Wounds of nerves by the modern rifle bullet present certain peculiarities, particularly when the missile is at high velocity. Like the tendons, the nerves are much more apt to be cut by the new bullets than they were by the old, and in fact they rarely escape if they lie in the path of the missile. The distinctive peculiarity of nerve wounds is that, from the delicate and dense structure of a nerve, the energy of the missile is readily transmitted and causes what the Germans call a violent "Erschütterung" (shaking) of the nerve. This effect may occur when the bullet is at high velocity even though it barely graze the nerve, the transmission of the missile's energy producing violent motions in the molecules of the nerve which lead to rapid deterioration of its structure. When a nerve is impinged upon by a high-velocity missile, the injury to the nerve is therefore not confined to the immediate area of destruction, but the molecular disturbance extends both proximally and distally. This makes the treatment of solution of continuity of nerves by bullet wounds, especially if the missile was at high velocity, much more difficult than solutions of continuity produced by cutting instruments. In the latter case there is no dissemination of destruction and the nerve can be readily united. In the case of bullet injury, not only is the nerve considerably lacerated and some extent of its continuity destroyed, but the molecular destruction may extend so far that union of the nerve, even if made, will not give restoration of function. In fact, operative treatment of wounds of the nerves by bullets has so far not been highly successful, and in no way compares with the favorable results obtained after proper operative interference in the case of nerves severed by edged instruments. In any case, operation to restore the continuity of a nerve should be done as soon as it can be effected under proper aseptic technic.

Discomfort and disability occur in some cases where the nerve is not directly wounded through involvement of the nerve in the cicatrix. These are favorable cases for operation, as the removal of the constriction or pressure upon the nerve usually gives relief. Referred pains are not uncommon in nerve injuries, the patient referring his symptoms, if pain be present, not to the nerve injured, but to some part to which a collateral branch is distributed.

Wounds of Blood-vessels.—On account of the high velocity of the bullet of the modern military rifle this missile rarely slips by the blood-vessels, but severs, perforates, or makes lateral wounds of them. These wounds are so cleanly cut that retraction of the walls of the vessel, leading to arrest of hemorrhage, is not so much favored as when the injury is made by larger and slower moving projectiles. When the walls of the vessel are not all cut, contusion or laceration without perforation may

result. This may occur when the rifle bullet strikes a vessel very obliquely. When the wall of the vessel is only partially torn or is devitalized by the impact of the bullet, *true aneurism*, that is, an aneurism the walls of which are formed by one or more of the walls of the vessel, may result. The weakened wall of the blood-vessel readily dilates and later gives rise to all the usual symptoms of true aneurism. On the other hand, should the cicatricial formation in the path of the bullet be strong, it may press upon and even diminish the caliber of the artery, this being evidenced by absent or diminished pulsation of the vessel distal to the wound. The true aneurisms formed in the way above noted differ but little from ordinary idiopathic aneurisms, except that they are usually more localized, and, having a thinner wall, give a more pronounced pulsation.

False aneurism frequently results when a vessel is perforated or only partially severed. After such an injury interstitial hemorrhage may occur, giving rise to a localized arterial hematoma held by the surrounding tissues. These tissues may organize into an inclosing sac continuous with the walls of the wounded vessel and opening into it. When continuity of the interior of the sac with the lumen of the vessel is established, the inflowing blood causes the pulsation which is sometimes noted, thus showing that an aneurism has formed. These false aneurisms are characterized by a soft, diffuse, fluctuating swelling, and, owing to the instability of their walls, are apt to increase rapidly in size.

Interstitial hematoma in its early stages is indicated by a diffuse, fluctuating swelling, and, if it be considerable, by the general symptoms of hemorrhage. Later, if the hematoma becomes organized, the tumor is quite hard and resistant to the touch.

Aneurismal varix and *varicose aneurism* have been frequently noted as a result of injury to blood-vessels by the small-caliber missiles in recent wars. These pathologic conditions are due to the passage of a bullet between an artery and a vein, wounding both vessels and at the same time producing a solution of continuity in the tissues between them so that the blood may pass from one vessel to the other. If the blood pass directly through without dilating the connecting channel, an aneurismal varix is established; but, if the new channel between the artery and the vein becomes dilated, a varicose aneurism corresponding in size to the dilation is formed. Such aneurism is really a false aneurism connected both with an artery and a vein. Aneurismal varix can usually occur only when the artery and vein lie close together, while if the vessels are somewhat farther apart a varicose aneurism is more likely to result. An aneurismal varix may occur and give rise to but little, if any, discomfort and to few symptoms. Locally it is evidenced by the existence of a purring thrill and a pulsating murmur. The symptoms of the varicose aneurism are usually those of a false aneurism, viz., a murmur and expansile pulsation of the tumor. The purring thrill is a distinct physical sign of both varix and aneurism and is usually present in the fully developed stage. Makins reported that in all cases he saw in the Anglo-Boer War of both aneurismal varix and varicose aneurism there was a decided increase in the pulse-rate, the pulsations reaching 100 to 140 per minute; and in the cases

of aneurismal varix this acceleration of the heart action was often the only symptom which particularly inconvenienced the patient.

The Treatment of Gunshot Wounds of the Blood-vessels.—*Hemorrhage* to a dangerous extent from wounds of blood-vessels by bullets depends not alone upon the size of the vessel wounded, but upon its situation and the tissues which surround it. A small-caliber bullet may partially or wholly sever quite large arteries of the extremities and no great hemorrhage result, the track of the missile through the soft parts being so small that the natural contraction of the tissues practically closes the wound and but little blood escapes. When a large vessel which lies superficially, such as the femoral, the carotid, or the axillary, or their accompanying veins, is wounded, the hemorrhage may be profuse and quickly fatal. When blood-vessels in the body cavities are wounded, dangerous internal hemorrhage is likely to follow even though the vessels be small ones, for in these cases there is no strong surrounding tissue to check the outflow of the blood.

In many cases hemorrhage from gunshot injury, particularly if it be in an extremity, will cease spontaneously if the wounded person be kept perfectly quiet, the limb elevated, and careful compression and cold be applied. The good effect of rest in internal hemorrhage is to be particularly emphasized. When the hemorrhage does not cease spontaneously or there is liability of its recurrence, the ideal treatment is proximal and distal ligation of the vessel in the wound. To carry out this procedure in bullet wounds it is necessary to enlarge the wound, and this should be done, when possible, under aseptic precautions. This ideal treatment cannot always be carried out, particularly in those cases in which the situation of the injury is such that the vessel cannot be readily reached at the point of injury. In such cases proximal ligation may be resorted to. When this is done, the surgeon should always bear in mind the dangers arising from the sudden arrest of blood following the ligation of the main artery of a part. The danger of gangrene following such operation is particularly present in the lower extremity, and especially if there is a large wound distal to the point of ligation.

Recurrent hemorrhage, after bleeding has stopped spontaneously, is often due to movement of the person wounded or to restoration of the blood-pressure after recovery from shock. In military surgery where the wounded have to be transported, the possibility of such recurrent bleeding should always be borne in mind, and, where there is likelihood of its occurrence, the wounded person should be kept as quiet as the conditions will permit. So, also, injudicious handling of the wounded or exploration of the wound is to be avoided.

Secondary Hemorrhage.—Secondary hemorrhage was formerly a comparatively common sequel in gunshot wounds. It is now known that infection is the main causative factor of this condition; the infection giving rise to necrosis of the tissue about the vessel and of the vessel wall itself, thus weakening the vessel so that it is readily broken, and, as the devitalized tissues do not contract, the hemorrhage is profuse and constant. Prevention of secondary hemorrhage by the maintenance of asepsis in

uninfected wounds, and, in infected wounds, by the use of mild antiseptic irrigation and complete drainage, is of prime importance in preventing this condition, for the tissues are thereby maintained in the best condition for repair.

The treatment of secondary hemorrhage is often difficult. Local compression is for only temporary use until operation can be resorted to. In those cases where the bleeding vessel is comparatively superficial and the wound in fairly good condition, the wound may be opened and the vessel ligated. In this procedure it is often difficult to find the vessel and to ligate it high enough to insure that the ligature is placed above diseased tissue. When this operation must be done, and through an infected area, the ligation should be preceded by thorough cleansing of the infected tissues, and should be followed by careful and thorough drainage. The ideal operation is to ligate both ends of the vessel through sound tissue on either side of the wound. When this cannot be done, proximal ligation of the main vessel or amputation has to be resorted to. Amputation may be preferred to proximal ligation, especially in the lower extremity when the case is a septic one and when there is much destruction of the soft parts, or when there is a large wound distal to the point of ligation. If the main blood-supply of an extremity in which there is an infected wound be cut off, the probability of gangrene or severe systemic infection is greatly increased. Great progress in the surgery of the blood-vessels has recently been made through the experimental work of Carrel and Guthrie, Page, and others, and it is possible that in favorable cases suture or cross-anastomosis of artery and vein may prevent or limit gangrene.

Gunshot Fractures.—Solution of continuity in bone by bullets differs in character according to the velocity and size of the projectile, the compactness of the bony structure, and the angle of impact of the missile. The maximum destructive effect is produced when a deformed missile at high velocity strikes compact bone. The minimum effect is produced when an undeformed, small-caliber missile strikes cancellous bone. In compact osseous tissue the energy of the missile is readily disseminated, giving rise to long fractures and extensive comminution. In the less dense cancellous tissue, such as the extremities of the long bones, an undeformed bullet may perforate with little or no fragmentation.

Fractures of the Diaphyses of the Long Bones.—When an undeformed rifle bullet strikes a bone the character of the fracture produced varies, mainly, with the velocity of the missile and the angle of impact. In general, it may be stated that the amount of damage done in the diaphysis of a long bone by a rifle bullet depends largely upon the range at which the injury is received and the consequent velocity of the missile, and that the amount of comminution decreases as the range increases. This general rule is subject to some variations. Median perpendicular impact gives rise to greater comminution than does a lateral oblique impact. Also, observations in the Boer War indicate that at long range considerable comminution of the shafts of long bones may be produced through the missiles striking with a more or less extended area of their sides. Toward the end of its flight the rifle bullet, instead of traveling with its point

to the front, oscillates, or wobbles, and may thus strike, not perpendicularly with its head, but more or less crosswise; and it thus strikes the bone harder than it would if it impinged head-on.

There are six types of fracture by gunshot: (*a*) incomplete, (*b*) Y-shaped, (*c*) oblique, (*d*) transverse, (*e*) X or butterfly, and (*f*) irregular fractures.

The incomplete form of fracture in the shafts of long bones is of two varieties. One form is that in which the shaft is simply grooved or a fragment chipped off by a bullet striking the bone very obliquely. This form of fracture is usually produced only by a bullet traveling at quite low velocity. The second incomplete form of fracture is that in which the bone is perforated with but short fissuring which does not extend to the sides. This incomplete form of fracture is rarely seen, and then usually only toward the extremities of the largest bones, such as the femur and tibia.

The Y-shaped fracture is usually produced in the same way as the incomplete fracture above described, except that the bullet strikes the bone nearer the median line, and not only chips off a V-shaped fragment, but produces a transverse crack extending from the apex of the V across the shaft.

The oblique fracture is by far the most common, and, even when the shaft of a long bone is badly comminuted and when considerable displacement of the fragments is produced, the main line of injury can usually be seen to be oblique. This form of fracture may be produced by a bullet striking the bone with any except the highest velocity.

Transverse fractures by rifle bullets are rarely seen, but may occur when the bullet is at very low velocity and strikes the bone with only sufficient force to crack it.

Butterfly, or X-shaped, fracture is produced when a bullet strikes the median line of a bone perpendicularly to its long axis. In such case, if the bullet passes through the bone, it makes a hole from which the lines of an X radiate. If the missile is at high velocity, great comminution of the bone in all directions may occur and the lateral fragments may be driven considerably outward.

The irregular types of fracture are mostly produced by deformed bullets or by undeformed bullets at high velocity striking the median line of the shafts of the long bones. Under such conditions, and especially when a high velocity missile deforms and presents a mushroom head to compact osseous tissue, the impact of the missile is so great that the bone is broken into many fragments and a true explosive effect is produced. These wounds are often very serious; not only is the tissue destruction great, but the bone fragments are driven forward, destroying the soft parts and producing a large wound of exit sometimes several inches in diameter.

Comminution in Fractures.—The fragments into which compact bone may be reduced by bullets may be divided into three groups: (*a*) fine bone dust or débris caused by direct impingement of the missile, (*b*) small splinters up to one inch in length produced as the missile passes through the shaft, and (*c*) the larger fragments due to the outer fissuring.

Bone dust is produced by direct impact of the missile and is seen in all cases where a bullet passes through the bone. The number of small splinters is mainly proportionate to the velocity of the missile and the density of the bone. They are consequently very numerous in an explosive wound, are frequently much displaced, and are the principal cause of the laceration of the soft parts in these injuries.

Fractures of the Epiphyses of Long Bones.—As above noted, the cancellous structure of the extremities of long bones offers but little resistance to a missile, therefore does not readily transmit its energy, and perforation with little fragmentation is the rule when the projectile is undeformed. Clean-cut perforations are often seen, and, if the fracture be complete, there are usually but one or two radiating fissures. The minimum amount of fragmentation of the extremity of a long bone is, of course, possible only when the extremity of the bone is of considerable size relative to that of the bullet, and it therefore occurs only in the epiphyses of such large bones as the femur, tibia, and the head of the humerus. When the extremity of the bone is not much larger than the missile, there is generally great destruction.

FIG. 503.—COMMINUTION OF HUMERUS (Stevenson: Report, South African War).

When the extremities of the larger bones are simply grooved or perforated by a bullet, the fracture may be made complete by the body-weight being thrown upon the bone after receipt of the wound, and an incomplete fracture be thus made into a complete one.

When a rifle bullet is deformed, marked comminution of the epiphysis is the rule, the large striking surface of the missile making up for the non-resistant structure of the bone.

Fractures of the Flat Bones.—In fractures of the flat bones much depends upon the size of the missile. When the bone is very thin, or cancellous in structure, the missile may perforate with little fragmentation, producing a hole not much larger than the area of cross-section of the bullet. In the flat bones of the skull, on account of the density of their structure, considerable fragmentation is usually produced unless the bullet is traveling at very low velocity, when quite clean-cut, punched-out holes are common.

The **diagnosis of gunshot fracture** is usually not difficult. The most pronounced symptoms are the extreme abnormal mobility of the part, especially if the fracture be of an explosive type, and the little or no shortening of the limb. When a fracture is incomplete, it is often of

moment to determine this fact, for an incomplete fracture may so weaken the bone that unless it is protected a complete fracture will result. The use of the *x*-ray is of great value in these cases, and in fact it should be used in all cases whenever possible, for it is only by the use of this agent that the exact character of the fracture and the position of the bone fragments can be determined.

Treatment of Gunshot Fractures.—The recognition of the fact that many gunshot wounds are uninfected has greatly influenced the treatment of gunshot fractures. In uninfected wounds, where there are no special factors, such as displaced bone fragments, which might interfere with the future function of the part, the fact of non-infection enables the surgeon to treat these cases as he would simple fractures, and has consequently given rise to much greater conservatism in military surgery. Another factor which has materially influenced the treatment of gunshot fractures has been the use of modern methods of antisepsis in infected wounds, for by the use of these methods the surgeon is able to more or less control the extent of infection and the inflammation which may result. The consequent trend, therefore, of military surgery has been toward rather extreme conservatism in fractures caused by gunshot. In fact, it may be stated that recognition of the uninfected nature of many gunshot wounds, with consequent application of the principle of non-interference, and the treatment of infected cases by modern surgical methods, have been the essential factors in saving limbs and lives. Even as late as the Franco-Prussian War the theories of asepsis and antisepsis had not so far influenced the practice of surgery as materially to do away with the old ideas of radical operation and the consequent general resort to amputation in gunshot fractures of extremities. In the older days amputation was the rule in such injuries of the upper and lower limbs, while now it is the exception. In general, it may be stated that the presence or absence of infection in gunshot fractures is the main factor which determines the treatment of the case.

The next factor of importance is the displacement of bone fragments, that is, if the fragments are so displaced that they press upon important structures or are so situated that they may prevent proper repair of the part. In general, the factor of least importance is the amount of comminution which is present, especially if the wound be uninfected.

In uninfected fractures operation will be rarely required unless it be to replace displaced fragments of bone or to remove them. When such operation is necessary, it should be done only under the most rigid aseptic precautions. Displaced fragments of bone still united to the periosteum should be put in place, wired there if necessary, the free fragments removed, and the limb dressed after inserting a small drain, which, if the wound proves uninfected, can be removed at the end of forty-eight hours.

In infected wounds operation should always be done. The seat of fracture should be exposed, preferably along the line of entrance of the missile, all loose fragments of bone should be removed, and the wound very carefully cleansed in order to remove all foreign material. Free drainage should be provided and antiseptic treatment carried out.

In some cases of infected compound fractures by gunshot these conservative methods are not followed by recovery. The infection spreads along the long fissures in the bone and into the medullary cavity, producing chronic ostitis or osteomyelitis. By the use of antiseptic measures such inflammatory process may be kept more or less localized and systemic infection prevented, but necrosis of the bone will occur, and suppuration, with all the debilitating effects due to inflammation, will persist. In such cases a second attempt may be made to clean out the focus and remove the trouble. But in some cases the infection is so disseminated that this procedure will prove unsuccessful and amputation will be required. There is an evident tendency in cases of bad infection of the larger bones of the extremities to carry conservative treatment too far now that the more acute inflammatory symptoms can be controlled by antiseptic measures. Such ultra-conservatism is to be avoided, and the surgeon should not hesitate to operate as soon as he sees that local measures are inadequate.

Gunshot Wounds of the Joints.—Until recently, gunshot wounds of the large joints ranked next to those of the body cavities in gravity, and even now these wounds give rise to serious concern when the joints are laid widely open or are infected. But, as with gunshot fractures, the treatment of gunshot wounds of the joints and results obtained by treatment have been radically affected by the adoption of aseptic and antiseptic methods. Previous to modern surgery, radical operation was generally advocated in gunshot wounds of the knee and elbow, and even of the ankle and wrist. Amputation was especially recommended in wounds of the knee, and was not recommended in wounds of the hip-joint only for the reason that the operation of disarticulation at the hip was as dangerous as was letting the case alone. To von Bergmann is due the inauguration of the practice of conservative treatment in gunshot wounds of the joints in the surgery of war. Von Bergmann noted that 95 per cent. of all cases of knee-joint injury treated by the old methods of amputation or digital exploration died. In the Russo-Turkish War, therefore (thinking, doubtless, that no worse result could be obtained by other methods), he concluded to try non-interference and the use of immobilization and occlusive dressings. His results were startlingly good, for in fifteen serious cases of gunshot wound of the knee in which there was implication of the joint with extensive comminution of the bone, he lost but one case, this requiring amputation, the others recovering with movable joints.

We now see that the change in military surgery from radical operation to conservatism, with the saving of life and limb in wounds of the joints, has been made possible by several factors. The first of these is the recognition of the fact that many wounds by bullets are uninfected, and that therefore non-interference and occlusive dressings are all the treatment required. Of less importance, and having a bearing upon the future use of the limb, is the fact that the fractures of the ends of the large, long bones by bullets are not much comminuted, and that displacement of the bone fragments is generally slight. As before stated, the resistance offered to a bullet by the cancellous structure of the ends of the large bones is so slight that the missile expends but little of its energy, and as a result the bone

lesion is usually a grooved or clean-cut tunnel. Even when this groove or tunnel communicates with the joint cavity, it usually fills quickly with exudate, and, when repair has occurred, often gives rise to no ill after-effect. In any case, when the wound is uninfected, ankylosis of the joint is the most serious result that can follow. This can usually be rectified by breaking up the adhesions under anesthesia or by operation if considered necessary. However, the limb may be sufficient for most purposes in its ankylosed condition. Ankylosis, when it occurs in these cases, is usually due to displacement of bone fragments or to fibrous union. This result is more likely to follow gunshot injuries of the smaller joints, for the bones of these articulations are so small and brittle and so closely articulated that slight irregularities of the joint surfaces or displacement of the bones is apt to interfere with normal motion.

Infection of the joint cavity, unless promptly and immediately controlled, is an even more general cause of ankylosis, and any manifestly infected joint wound should receive the most careful aseptic and antiseptic treatment. The joint should be opened, the joint cavity thoroughly washed out, and drainage instituted. Such cases may recover with movable joint, but ankylosis is generally the best that can be hoped for. Should the infection progress, amputation may have to be resorted to.

The success which has followed the adoption of conservative treatment of joint wounds in war is shown by Haga's statistics of the Japan-China War and by those of the Spanish-American War as compared with the figures for the American Civil War and the Franco-Prussian War. The general experience of surgeons in the Anglo-Boer War and the Russo-Japanese War has been similar, although the exact statistics of these are not yet available.

PERCENTAGE MORTALITY FROM WOUNDS OF THE JOINTS IN FOUR WARS.

Joint.	American Civil War.	Franco-Prussian.	Japan-China (Haga).	Spanish-American (Regulars).
Hip	84.7	71.8	100.0	0.0
Knee	53.7	48.9	25.0	5.5
Ankle	26.9	24.0	0.0	0.0
Shoulder	31.1	35.5	0.0	0.0
Elbow	9.4	21.2	0.0	0.0
Wrist	12.9	12.6	0.0	0.0

In the American Civil War gunshot wounds of the hip-joint were nearly as fatal as injuries to the skull, brain, spinal cord, and abdomen. Wounds of the knee-joint followed with a mortality of 53.7 per cent., while of the eighteen cases reported in the regular troops in Cuba there was but one death, and that followed amputation. In military surgery the conditions relating to wounds of the larger joints are very like those present in penetrating wounds of the abdomen. In all these cases there is a possibility that the wound is aseptic and that it may be made septic by

operation if the operation be attempted at some place in the field where aseptic precautions cannot be properly carried out. With proper aseptic technic the surgeon, when necessary, may open a joint as fearlessly as he would the abdomen, but under the usual conditions of military surgery and in view of the high mortality from operation and the good results of conservatism, the military surgeon is not warranted in opening joints unless he can take proper aseptic precautions or the life of the patient is in imminent danger. Where the joint is manifestly infected no harm can be done by operation, even though asepsis be not perfect, for the use of antiseptics and drainage is indicated. The need for such treatment ordinarily arises in the case of wounds from shells or deformed missiles. In these cases the operation which will best serve will have to be determined for each case, and, if the choice lies between excision and amputation, due consideration must be given to the fact that amputation is not equally available in all joints. In general it may be stated that where bone and tissue destruction is not too great, the experience of military surgery has shown that excision is preferable to amputation in all cases except in the knee and ankle. With aseptic and antiseptic technic it is quite probable that more excellent results may be obtained in these joints in the future than has been in the past, and under these conditions excision may be practised in any joint with greater hope of success than was possible with the old surgery.

Formal *excision* as an early, systematic, operative procedure in gunshot wounds of the joint will be rarely indicated in the future. When the articular surfaces are so extensively comminuted that excision may be thought of, the joint will also generally be infected. In cases in which the infection can be controlled, the removal of all loose fragments, followed by antiseptic treatment and complete drainage, will be the operation indicated. In a certain number of cases, however, a formal excision may be preferred rather than the more radical operation of amputation.

Amputation will be indicated when the amount of destruction of the soft parts about the joint is great or the blood-supply to the limb below is cut off. More rarely, though occasionally, excessive comminution of the bones, especially in connection with advanced infection, will indicate the removal of the limb. Where the large vessels and nerves of a limb are severed, even though the limb be saved, it will usually be atrophied and paralyzed. Conservatism in such cases, especially if accompanied with distinct danger to the patient's life, is hardly desirable; but the surgeon is warranted in proceeding more conservatively with the upper than with the lower extremity.

While *conservative methods* are to be generally used in military surgery, it should be pointed out that such conservative treatment of joint wounds does not always mean non-interference. Non-interference is indicated only in those cases which by their progress show that the joint is uninfected, or when, in spite of manifest destruction of the joint, the surgeon cannot operate because of lack of aseptic control. Conservative treatment means treatment directed toward saving the limb and the function of the joint. It may therefore include aseptic operative opening of the

joint, the removal of loose bone, lodged missiles and foreign material, and, when necessary, antiseptic cleansing and drainage.

Lodged Bullets in Joints.—The fact that a bullet has opened the cavity of a joint has no bearing on the condition or treatment of the case unless infection is present or the bullet is lodged within the joint cavity itself. If there is no infection and the bullet is lodged in the ends of the bone and does not protrude into the joint, there is no more indication for removal of the bullet than if it were in any other part of the body. When the bullet lodges in a joint cavity or in the articular surface of a bone, it may give rise to pain or limitation of movement. In such cases extraction of the missile is required. The removal of a bullet from one of the large joint cavities is not always easy. Before attempting the operation the exact location of the missile should be determined by the use of the *x*-ray so that the operator may know exactly where to look for it. To open one of the large joints in which a bullet is lodged and search for it before it has been definitely located, most commonly results in failure. The bullet will rarely be found free in the joint cavity or protruding from the articular surface, and, if it is embedded in the head of a bone, it can neither be seen nor touched. Exact localization by *x*-rays by Sweet's method (see Vol. V) is therefore of great importance and practical necessity antecedent to attempts at removal.

Infection in Gunshot Wounds.—Infection of gunshot wounds may be either primary or secondary; primary when the infectious material is carried in with the bullet at the time the injury is received, and secondary when it is introduced at any later time.

Infection and non-infection of a gunshot wound are of such great importance relative to the prognosis and treatment of the injury that the factors which determine these conditions should be thoroughly understood. The size, shape, and velocity of the missile producing the wound, and certain conditions incident to the individual wounded, such as the degree of cleanliness of the skin and the condition of the overlying clothing, are the main factors which determine infection or non-infection in these cases.

Factors Pertaining to the Missile which Influence Infection.—The bullet itself can convey infection directly into the wound, provided it has been infected before firing or passes through infectious material before entering the body. It was thought that a missile infected before firing would be sterilized by the heat generated in the weapon by explosion of the powder, but this has been proved not to be the case. In their original packages the majority of cartridges are free from septic germs. This condition of the cartridges is due to the disinfection and cleanliness observed in the process of manufacture. The cartridges, however, are not commonly sterile when placed in the piece, for, as they are usually carried in the cartridge-belt and handled by the soldier, they become contaminated with pyogenic micro-organisms, the bacillus of tetanus or other pathogenic germs. The heat and friction generated by the discharge of the missile from the piece will partially, but may not entirely, destroy the micro-organisms by which the bullet is contaminated.

Fortunately in most cases the bullet is so little contaminated before it is fired that the act of firing sufficiently sterilizes it, so that, though it may carry some few micro-organisms into the tissues, the natural resistance of the body is sufficient to destroy them before they produce pathologic changes. But when the bullet is so contaminated that the act of firing does not sufficiently sterilize it, or when after firing it becomes contaminated by contact with dirty objects before it strikes the body, it may cause infection. Ricochet impact against some soiled body may contaminate the bullet, or by changing the shape and increasing the size of the missile may enable it to carry more infection into the wound when it passes through soiled clothing or skin.

The size of the missile is of importance, the general rule being that the larger the missile, the more apt it is to infect the wound. A missile presenting a large front is more apt to carry foreign material into a wound than one with a small front area; and with large missiles, the entrance and exit wounds being large, the liability to secondary infection from entrance of foreign material through the larger wounds is increased. In fact, the size of a gunshot wound bears a direct ratio to its liability both to primary and to secondary infection.

The shape of the missile producing the injury also has a definite bearing upon infection. The smooth, oval head of the modern rifle bullet allows it to penetrate objects easily, and this, with its high velocity, enables it to enter the body so quickly that it is little likely to push deleterious material into the wound. When a bullet is deformed, it presents a broad irregular face which is more apt to carry foreign material into the wound; and, if the missile has sufficient velocity to perforate the part, it will produce a large jagged wound of exit into which secondary infection is very liable to find its way.

The irregular shape and generally large size of shell fragments are the main causes of primary infection in wounds by these missiles. It is true that very small fragments of shell may be driven into the body and produce no infection, but with large fragments this rarely occurs, for, if they pass through the clothing, they almost always carry pieces of it into the tissues; and, if the skin of the soldier be soiled, the entering missile is nearly sure to carry material from it into the wound. Shrapnel bullets are probably somewhat more likely to carry infection into a wound than are rifle bullets, for the reason that they are somewhat larger and their surface is not so smooth. But, as before noted, quite a proportion of the wounds by these missiles are uninfected.

High velocity of a missile appears to favor non-infection of the wound, particularly if the missile pass completely through the part. An undeformed missile with high velocity appears to pass through the clothing and skin so quickly that it does not carry much deleterious material into the wound, or, if it does, it carries much of the adherent material out with it. With low velocity, inpush of material is much more apt to occur, particularly if the bullet has been deformed.

Factors Pertaining to the Individual Wounded which Influence Infection.—The condition of the skin has much bearing relative to in-

fection, both primary and secondary. Where the skin is clean, or fairly so, the wound is much less apt to be infected than when the skin is soiled. Hence wounds received in summer, or when men have had opportunity to bathe frequently, are less likely to be infected than are wounds received in winter campaigns, when soldiers have little opportunity to keep themselves clean. Wounds of the hairy scalp and wounds of the hands and feet are much more likely to be infected than are wounds of most other parts of the body, these parts being particularly likely to be soiled and difficult to keep clean.

The character and condition of the clothing is important, not only in itself but in connection with the underlying skin. Experiments have definitely determined that minute particles of clothing are driven into the tissues in every case of gunshot injury, even those produced by the jacketed rifle bullet. In wounds from these small missiles the particles of clothing carried into the wound are almost always microscopic in size; but with irregularity in the missile or increase in its size, correspondingly larger pieces of clothing are apt to be driven into the wound. If the clothing be of cotton, undeformed bullets ordinarily make slit-like holes through it and carry a minimum amount of the material into the wound. In woolen clothing the holes are more punched-out and a greater amount of the cloth is apt to be indriven. The thicker the clothing, the more likely is it that a greater amount will be carried into the wound. It follows that a reasonably clean skin, covered by comparatively thin and clean cotton clothing, does not favor infection, while a dirty skin and thick, soiled, woolen clothing distinctly favors this condition. Hoff has particularly noted this in his publication relative to the wounded in the Russian army in the late war with Japan. He states that in summer, when the men wore comparatively light clothing and were able to bathe frequently, a large majority of the bullet wounds were uninfected; but in winter, when the men wore heavy woolen clothing or sheepskin coats and were not able to bathe, the body and clothing became very dirty, and nearly all wounds, even those by the small rifle bullets, were infected.

Secondary infection is particularly favored by exposure of the wound or injudicious handling. Unless the wound be very small and quickly closed by the drying blood, infected material is apt to be carried into it either from the air or from friction by the overlying clothing. Injudicious handling of wounds has been a most important agent in causing their secondary infection in the past, and the immediate protection of gunshot wounds by the application of the first-aid dressing is of the greatest value in preventing this occurrence.

In determining the question of probable infection or non-infection of a wound, a surgeon should take into account all the foregoing conditions. If the wound was immediately protected by a properly applied first-aid dressing, there is little probability that it has been secondarily infected. If this be removed carefully, the appearance of the wound, together with the condition of the surrounding skin and the character of the clothing, will be of importance in enabling him to reach a tentative conclusion. It is true that in many cases it will be impossible to determine definitely whether a

wound has been infected or not, for a perfectly innocent appearing wound may be infected, while a much larger and more ragged one may be uninfected. In any case conservatism should be practised at the first lines of assistance and no doubtful case should be meddled with until it has reached a place where it can be explored under aseptic conditions unless an immediate exploration is required in order to save the life or limb of the wounded person.

The Micro-organisms which Produce Infection.—The micro-organisms which produce infection in gunshot wounds are most commonly the staphylococci, less frequently the streptococci, bacillus pyocyaneus, and the tetanus bacilli or some other pathogenic or saprophytic micro-organisms. Staphylococcus infection is most common, for the reason that it is constantly found on the skin or clothing. When this germ produces infection, localized inflammation and abscess formation are the rule; but, if treatment of the case be delayed, the infection will gain such hold that severe inflammatory extension leading to loss of life or limb may result. Before the days of antiseptic surgery, when wounds were treated by digital exploration and wet dressings, such extension of inflammatory action was very common, and was the frequent cause of metastatic abscesses, pyemia, and other serious or fatal conditions.

With streptococcus infection, diffuse inflammation with involvement of the lymphatics, systemic toxemia, and other conditions grouped under the general term septicemia are likely to occur.

In many cases the infection will be a mixed one, staphylococci and streptococci both being carried into the wound, and in such cases the pathologic effects of both germs will present themselves. The bacillus coli communis, either alone or with the staphylococcus or streptococcus, is generally prominent in pathologic action in all wounds involving the intestinal tract. The tetanus bacillus, while a less frequent cause of infection than are the micro-organisms above named, is usually present in a certain number of cases. In the 246,717 wounded reported in the American Civil War, 505 cases of tetanus occurred. In the Spanish-American War but one case of tetanus was reported. Stevenson, in his "Report on the Surgical Cases Noted in the South African War," states that but three cases of tetanus occurred in the South African campaign.

Although infection by the tetanus bacillus is comparatively infrequent in ordinary campaigns, under certain conditions the disease is very prevalent. Von Oettingen states that, while tetanus was comparatively infrequent in summer, after the battle of Mukden in winter approximately one per cent. of all the wounded died of tetanus. He ascribes the great frequency of tetanus after the battle of Mukden to the transportation of the uncared-for wounded in large numbers in unclean cattle-cars. He does not mention other conditions which were probably also partly responsible, viz., the extremely unclean condition of the soldiers, their thick clothing and sheepskin coats. Von Oettingen further states that most of the cases ended fatally and that the antitoxin used was without effect. The possibility of the occurrence of tetanus should always be remembered, for gunshot wounds seem to particularly favor this condition.

The tetanus bacillus is anaërobic, the ordinary gunshot wound is of a deeply punctured character, the bullet may carry the bacilli deeply into the tissues from which air is excluded, and thus all conditions are present which favor the growth and development of this particular micro-organism.

In considering infection in gunshot wounds the surgeon should give great weight to the measures by which secondary infection may be prevented. Under the conditions in which wounds are received in war the surgeon can do little, if anything, to prevent the primary infection of the wound, and his practice must therefore be particularly directed toward preventing secondary infection when primary infection has not occurred. It is true that on shipboard before an engagement he may be able to see that the men have recently bathed and have put on clean underclothing, and in field campaigns he should urge cleanliness as much as is consistent with the conditions of the campaign, thus reducing the possibility of primary infection. However, owing to the conditions which obtain in war, the treatment of the case after the wound has been received is usually the only line along which the surgeon can work. Constant vigilance should be exercised to prevent a non-infected wound from becoming infected, and to prevent increased infection in a wound which has been only slightly contaminated. The value of instruction of men in the proper use of the first-aid packets, so that they can apply them without contaminating the wound, is therefore manifest.

Lodged Missiles.—Previous to experience in war it was the general opinion that lodgment of the modern small-caliber rifle bullet would be comparatively rare. Experience has demonstrated that quite a large number of bullets remain in the tissues. This fact would seem to be opposed to the general statement that the modern rifle bullet has great penetrating power, for increased penetration would seem to include increased liability to pass completely through a part. The fact is that the modern rifle bullet is little likely to lodge in a part unless its velocity be greatly decreased, but with greatly decreased velocity the missile is so light that it is readily arrested. The bullet, from its high velocity and resistant envelope, frequently ricochets and has sufficient velocity remaining after the ricochet to enable it to inflict a wound, but not to perforate the part. Also, if the missile is deformed by ricochet or turned end for end or strikes the body side-on, it is much more likely to be arrested. It has been noted that the great majority of lodged missiles are either deformed or lodged butt-end first in the tissues, while the lodgment of absolutely undeformed rifle bullets is comparatively rare. It is noted also that, even though arrested in the tissues, the modern rifle bullet is rarely deflected by them, but goes in a straight line from the place of entrance to the place of lodgment; in this way differing from the larger, slow-moving lead bullets of the old type, which were frequently deflected in their course by resistant tissues.

Infection in cases of lodged bullets is comparatively rare when the bullet is undeformed or but slightly deformed and has passed through fairly clean skin and clothing. When the bullet is much deformed, in-

fection is much more liable to occur, and, as before noted, lodged fragments of shell are very apt to produce this condition.

Treatment of Lodged Missiles.—When a missile is uninfected it generally becomes encysted in the tissues and causes no trouble unless it presses upon a nerve or interferes with the motion of a joint. In some cases knowledge of the presence of a bullet within the body gives rise to mental disquietude even though the missile is doing no harm. In case of lodgment the questions for a surgeon to determine are whether or not to remove the foreign body, and, if it is to be removed, when the operation should be done. It may be said that a lodged missile should always be removed when it is producing distressing or dangerous symptoms, if the removal is possible and if the operation does not endanger life or necessitate operative trauma which will produce more ill effect than will arise from allowing the missile to remain. If the missile is producing pain or discomfort, it should be removed, provided it can be removed with safety to the patient; but it would be impracticable to remove it or attempt to remove it if the operation entails more danger than would the continued presence of the foreign body or the possibility of future trouble or discomfort to the patient.

As to when a lodged missile should be removed, the answer is that it should never be removed except when aseptic technic is available, unless the danger arising from its presence is greater than that likely to follow an operation under septic conditions. In a great majority of cases there is no pressing, immediate necessity for the removal of a lodged missile. Most cases can safely wait until removal can be done under aseptic precautions. Probably no single procedure in the past did so much to increase the mortality in gunshot wounds as the immediate search for and removal of bullets. It was the common practice to immediately explore a wound, with either the fingers or a probe, the surgeon being entirely unaware of the harm he was doing. Probing a bullet wound to determine the location of a bullet should be done only in extremely exceptional cases, and then under conditions of rigid asepsis. The very act of exploring a bullet wound may, by the additional trauma inflicted, reduce the natural resistance of the tissues to such an extent that inflammation will occur in a wound which would otherwise go on to uninterrupted healing. As before noted, small particles of clothing and foreign material are carried into every bullet wound. The amount of contamination may not be sufficient to produce infection unless there is secondary trauma through injudicious handling or probing. This supports the statement before made that immediate operation for lodged missiles should not be done, and especially that the wound should not be explored under septic conditions, unless the immediate danger from the presence of the bullet is greater than the possible consequences which may arise from interference. When it is necessary to use a probe or to explore a wound, the strictest aseptic precautions should be observed. In many cases it is impossible to locate a missile by use of a probe or exploration of the wound. The bullet may be lodged too deeply or the contractility of the tissues and change of position of the patient may cause such shifting of the muscles and fascial structures as completely to obstruct the path of the projectile. Every surgeon has

experienced this difficulty, and the further one that it is not always possible to determine if the missile is touched by the probe even when it has been reached by that instrument. A lead bullet will leave a mark on the porcelain tip of a Nélaton probe, but the jacket of the modern rifle bullet leaves no trace, and the sensation of contact with the missile as differentiated from that of contact with fibrous tissues or bone is often not sufficient to enable the operator to determine that the probe is in apposition with the bullet. The telephonic probe overcomes this difficulty, and it may be used in cases where removal of the missile is imperative and the *x*-ray cannot be employed. But it is open to the same objection as the ordinary instrument, viz., the difficulty of passing it through the bullet track, the possibility of injury to the tissues, and the likelihood of inducing infection. The *x*-ray should be used exclusively for the location of lodged missiles whenever it can be had. Its great value lies in the fact that it makes possible the localization of a missile without any trauma to the patient and its removal through the safest anatomic course, for, having located it, the surgeon is not required to go through the original wound, but can make his incision in the place best available for reaching it. Ordinarily, simple direct observation by the *x*-rays will determine the position of the missile with sufficient accuracy, but when the missile is deeply lodged, some form of localizing apparatus or, in those parts of the body where it is possible so to do, observations made at right angles will enable the surgeon to determine the exact position of the missile.

In shell-wounds, especially when these wounds are known to be infected, it is usually best to explore directly through the wound, the conditions being quite other than those which ordinarily obtain with lodged bullets.

Many different kinds of bullet forceps have been designed, most of them to the end that they may be introduced into the bullet track itself, and these instruments, of which the one designed by Senn is as good as any, may be used to advantage when the bullet has to be removed through the original wound. But where the bullet is removed, as it ordinarily should be, through a special opening, no such special instrument is usually required, except possibly in removing bullets from the brain. The bullet is best found by introducing the finger through an incision sufficiently large for the purpose, and then it can be readily removed with any toothed forceps. If the wound is uninfected, it may be closed without drainage; but if infected, in addition to the removal of the bullet the wound itself should be thoroughly cleaned out and an efficient drain introduced.

The Early Treatment of Gunshot Wounds.—The conditions accompanying gunshot injury which usually require immediate attention are hemorrhage, shock, pain, and the local conditions which obtain at the seat of injury.

Hemorrhage, when it occurs in amount sufficient to require special treatment, is evidenced by profuse bleeding from the external wound or by the constitutional symptoms of loss of blood. In wounds by bullets bleeding from the external wound is comparatively rare; the hemorrhage is usually internal and is evidenced only by the constitutional symptoms. When the loss of blood is rapid, the symptoms are pronounced and alarm-

ing. The face becomes deadly pale, the extremities cold, the pupils dilated, the pulse small and rapid, the respirations rapid and shallow and interrupted by yawns and deep sighs. If the hemorrhage be slower, the same symptoms appear, but they come on more gradually and are less pronounced. The patient suffers from distressing thirst and vomiting, is restless, complains of roaring noise in the ears, and air hunger is evidenced by the deep yawns and sighs. The treatment must necessarily depend upon the vessel wounded and the conditions under which measures for relief can be carried out. If the vessel be of an extremity or located superficially, the application of a tourniquet or direct pressure may check the bleeding until the surgeon can resort to the necessary operative interference. When the hemorrhage is of the body cavities, the case is much more difficult of treatment, especially on the field of battle. The most that can be done there is to give the patient complete rest if possible, trusting that the natural contractility of the vessels and the coagulation of the blood will stop the bleeding. When the hemorrhage is complicated by shock, the difficulty of treatment is increased, for, unless the vessel is secured, the methods employed to overcome the shock may cause an increase in the outflow of blood or its resumption if it has ceased. If the danger from the hemorrhage is imminent, operation must be done to secure it even before recovery from shock occurs, and, the vessel being secured, efforts may be made to support and revive the patient by the use of cardiac and cerebral stimulants and an intravenous or hypodermic use of normal salt solution.

Shock is seldom pronounced in wounds from bullets unless the bullet has struck one of the body cavities or a vital organ, but is commonly present when any part of the body has been struck or a limb carried away by a heavy fragment of shell. When shock is pronounced, the surface of the body becomes cold, the pulse weak and fluttering, the respiration feeble and shallow, pallor and faintness come on, and vomiting is not uncommon. Mental hebetude is more common in shock, while restlessness and anxiety are generally more pronounced in hemorrhage. If the shock disappears, all the conditions above noted, and which indicate prostration, give place to a more or less normal condition of the body, but, if the shock be complicated by hemorrhage, the symptoms continue until the hemorrhage is checked. The effect of shock on hemorrhage is generally favorable, for the lessened impulse of the heart's action and the prone position of the person wounded favor the cessation of the bleeding. With recovery from shock hemorrhage may return in quantity, and, bearing this in mind, the surgeon should adopt means for controlling the hemorrhage at the same time that he carries on those for relief of the shock.

In severe shock measures for immediate relief should be undertaken, for severe shock may rapidly pass into fatal collapse. The patient should be kept in a dorsal recumbent position and treated by application of heat, inhalations of amyl nitrite, hypodermic injections of strychnin, and the internal administration of alcoholics or of camphor and ammonia. In cases of both shock and hemorrhage the patient should not be transported until there are signs of safe reaction from shock or until the hemorrhage

has been controlled, and no operation of importance should be undertaken during shock, unless it be to stop bleeding.

Pain, following the infliction of gunshot wounds, may be temporary or persistent. Temporary pain is generally due to the impact of the missile, and disappears more or less rapidly. Permanent pain is due to the involvement of a nerve or to movement of the wounded part. The pain in wounds from bullets varies greatly. If the bullet make a flesh wound only, the pain is usually not severe, nor is it usually lasting unless a nerve be involved or pressed upon. If a bone be struck, the pain is much more severe, usually being compared to that from a blow by a heavy iron bar, while the pain from a flesh wound is usually spoken of as being more like a cut from a whip. Persistent pain is to be combated by immobilization of the part, suitable protection of the wound, and removal of fragments of bone or a bullet, if such be pressing upon a nerve. Persistent pain in a wound is sufficient cause for a thorough exploration of the wound under asepsis.

Local Conditions which Obtain at the Seat of Injury.—These have especially to be considered, either after hemorrhage and shock have been attended to or in connection with them. On the battlefield the attention of the surgeon has to be more particularly directed to the visible wound than to the deeper tissue traumas which have occurred. Volkman has said: "The fate of the wounded rests in the hands of the one who applies the first dressing." This statement has been emphasized by many later writers. The basic fact upon which this statement is founded cannot be too thoroughly impressed upon the surgeon who has to treat gunshot injuries, for the fundamental idea is that no additional injury should be done, either mechanically or by causing or allowing infection to be introduced. With this basic idea in mind, the statement can be taken with its proper limitations, for it is evident that, any additional trauma and infection aside, the fate of the wounded must rest to a certain extent in the hands of the surgeons who have to meet the many conditions which may arise later. *The prevention of secondary infection and unnecessary additional injury to the tissues is of the greatest importance in the treatment of gunshot wounds.*

In non-infected wounds by small missiles a blood-clot quickly forms in the small skin-wound. This soon dries, producing a dried blood-clot, which is nature's occlusive dressing. Under this scab, which opposes the entrance of foreign material and micro-organisms, the processes of repair go on with a minimum amount of interference. This natural protection of a wound should never be destroyed by the surgeon except when conditions relative to the deeper trauma demand it. Dryness of the wound and removal of all secretion favors the formation of a scab and lessens the liability of bacterial invasion. This condition of a wound is favored by aseptic absorbent dressings, and it is this action and its protective one which give the first-aid packet its particular usefulness.

In treating a wound which underlies the clothing the clothing should be at once cut away, thus exposing the part to the air and allowing the blood to dry in the opening of the wound and removing the possibility of the

in-push of foreign material through friction by the clothing. If sterile water is available, it may be carefully and gently poured over the wound and the surrounding skin, but under no conditions should ordinary water be used. It is much better to expose the wound to the air and apply dressings than to attempt any cleansing of the wound except under aseptic technic, and if, as is commonly the case on the battlefield, such cleansing is impossible, a first dressing should be at once applied. This first dressing should be absorbent and slightly antiseptic. Bichlorid gauze best meets these requirements, for of all the antiseptics, bichlorid of mercury is the one with which gauze can be most readily impregnated. When suitably protected by being wrapped in waxed paper or other occlusive covering, the gauze will retain its antiseptic qualities. Outside the gauze a layer of cotton should be placed to exclude bacteria and to assist in protecting the wound, and over all a bandage should be applied. Occlusive dressings of gutta-percha tissue, oiled silk, or other impervious substances should never be used. They exclude atmospheric air from the dressings, prevent evaporation of the wound secretions, and maintain heat and moisture under the dressing, thus producing the conditions most favorable to the growth of micro-organisms. The dressing should always be dry, and, if it become saturated with secretions, should be changed, for dryness of the dressing favors the desiccation of the blood and inhibits the growth of bacteria.

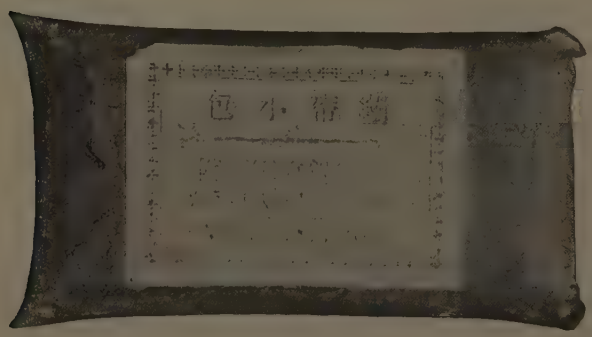

FIG. 504.—JAPANESE FIRST-AID PACKET.

The First-aid Packet.—In military practice in the field the first-aid packet is almost always used for the primary dressing of wounds. This dressing for bullet wounds is now supplied to the soldiers of all civilized nations, being made into packets of a size convenient to be carried by each soldier. The first-aid packet now furnished in the American army is put up in a light metal case which prevents its contamination or injury from moisture and retains it in good condition for application. The first-aid packet issued to other armies is in most cases inclosed in a covering of rubber cloth.

In **large wounds** dryness, protection, and drainage are necessary. The absorbent dressing should be large enough to cover the surface of the wound, and, if the wound be deep and lacerated, gauze should be loosely packed into it to insure drainage and dryness until proper methods of treatment can be instituted. Large wounds dressed in this way can be left undisturbed for several days provided the dressing is sufficiently large

to absorb the blood and protect the wound from outside contamination. The fact that large wounds, even though infected, after being packed with gauze can be left undisturbed for a considerable period of time without danger to the person wounded is of much importance. In military surgery operative procedures at the front can rarely be carried out, and it is fortunate that with absorbent dressings properly placed further treatment of the wounded can be delayed until they arrive at a field hospital where there are suitable facilities for aseptic and antiseptic work.

Fixation of the injured part is indicated in all except the very minor gunshot injuries. Rest of the wounded part, whether the trauma be of a soft part or a bone, is conducive to healing. In flesh wounds immobilization by slings, body bandages, or, if necessary, by splints will be required. In wounds of the chest and abdomen firm compression by bandages to limit the movement of their walls and to favor the cessation of internal hemorrhage is indicated. Immobilization of a wounded part is a distinct aid in preventing the recurrence of hemorrhage. Fixation of a part not only lessens the liability to a recurrence of hemorrhage, but, as it prevents the shifting of the dressing, it favors the formation of a dry clot of blood over the wound, and by preventing motion of the tissues enables repair to begin sooner and to continue with the minimum of interruption.

WOUNDS OF THE BODY REGIONS.

Because of the difference in area and position of the different regions of the body, the proportionate number of wounds of the various regions varies considerably. With hand weapons most of the wounds are of the head, upper extremities, and chest. Gunshot wounds are more regularly distributed, but this distribution is not in exact proportion to the target areas of the different regions; the head and the upper and lower extremities receiving somewhat more than their proportion of wounds, while the chest and abdomen receive less. Wounds of the different regions of the body differ greatly in gravity and in after-effect, owing to the differences in structure and to the presence of important organs in certain regions. The pathologic results, prognosis, and treatment of wounds are therefore materially affected by the importance of the organs or tissues injured and by the liability of certain tissues, particularly those lining the body cavities, to dangerous inflammatory reaction. In general terms it may be said that the mortality which follows wounds, especially by gunshot, is nearly in inverse ratio to the frequency with which they occur in the different regions. Thus, while the relative frequency of gunshot wounds of the spine is low, the mortality is exceedingly high, and, while wounds of the upper and lower extremities are common, the mortality is low. Modern methods of treatment and the adoption of the modern, jacketed, small-caliber bullet have materially affected the regional mortality of wounds in war. These two factors combined have reduced the total mortality of wounded who come under treatment, and have, particularly, reduced the mortality in wounds of the extremities and chest. In spinal

fractures and in fractures of the skull and penetrating wounds of the abdomen the reduction of mortality has not been so great.

	Cranial Region.	Spinal Fracture.	Face.	Neck.	Chest.	Abdomen.	Back (Flesh).	Pelvis, Perineum, and Genitals.	Upper Extremities.	Lower Extremities.
Frequency percentage:										
American Civil War as a standard	4.9	0.26	3.8	1.9	8.2	3.4	5.1	1.2	35.6	35.1
Mortality percentage:										
Civil War	28.9	55.5	5.8	15.0	27.8	48.7	6.9	29.7	6.5	13.8
War with Spain	19.8	66.6	7.5	18.6	9.5	42.6	1.6	0.0*	0.02	1.06
Philippine insurrection, 1899–1900	12.3	66.6	2.2	14.5	14.0	44.9	0.08	22.7	1.4	3.2

Wounds of the Cranial Region.—Flesh wounds of the head are of minor importance. Of the forty flesh wounds reported in the Spanish-American War, none were fatal.

Fractures of the Skull.—In fractures of the skull by hand weapons or gunshot the mortality is high. This mortality was not greatly reduced in the few cases (thirty-one) reported among the regular troops in Cuba during the Spanish-American War, as eighteen of these cases died; but in the one hundred and fifty-one cases reported from the Boer War, only forty-four died, or 33.1 per cent. This shows a decided improvement over the statistics of former wars. In the American Civil War 61.2 per cent. of all fractures of the skull terminated fatally, and in the Franco-Prussian War 51.3 per cent., so that the British mortality of but 33.1 per cent. shows a decided improvement, undoubtedly largely due to improved methods of treatment.

Gunshot fractures of the cranium are quite different from ordinary fractures of the skull produced by other agency. In ordinary fracture by direct violence the solution of continuity in the skull is the result of force applied to the skull with crushing effect over a large area and producing a comparatively slow indriving of the bone. In fractures of the skull by bullets the solution of continuity is produced by great energy concentrated upon a small area of the skull. At ordinary ranges practically the entire energy of the missile is expended at the point of impact, producing a localized solution of continuity in the bone but little larger than the area of the bullet and usually with short radiating fissures only. At very short range much greater damage is done, due to the molecular vibrations set up in the bone and the hydraulic effect produced by the sudden plunging of the missile into the fluid-saturated brain. The actual experiences of war show, however, that this hydraulic or explosive effect is not nearly so pronounced in living as in dead tissues, and the actual results in war do not therefore exactly agree with the experimental results obtained by firing into cadavers. Even at ranges as short as 100 yards fracture in the living subject is often confined to the entrance and exit

* Flesh wounds only, hence not to be compared with the others.

wounds with but short fissures, and the brain may be disintegrated only through the extent of the bullet track. At medium and long ranges the entrance wound is quite cleanly cut, but the exit wound is somewhat more irregular.

Fractures of the outer table without implication of the inner were not infrequent in the Boer War. But fracture of the inner table alone was very exceptional. The great majority of gunshot fractures of the skull are accompanied by symptoms of injury to the brain, these symptoms necessarily differing according to the part of the brain struck and the extent or character of the damage done.

Fractures of the skull by shell fragments or slow-moving leaden missiles, such as shrapnel bullets, may be of the simple fissure kinds, or depressed fractures without actual penetration of the skull by the missile, or extensive comminution of the bone accompanied by large apertures in the skull.

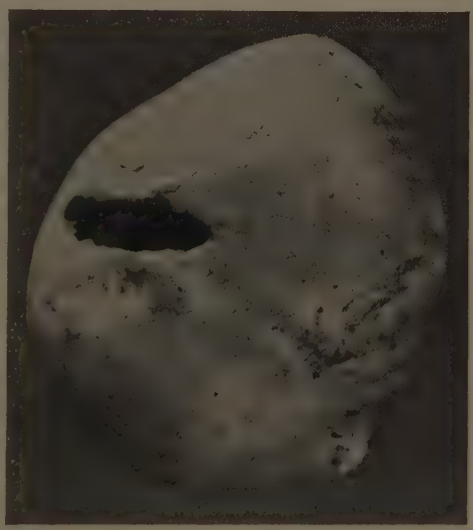

Fig. 505.—Gutter Fracture of Skull.
Patient died five months after receipt of injury (Stevenson: Report, South African War).

Fractures of the skull by rifle bullets are generally of three kinds: (1) gutter fractures; (2) penetrating fractures; (3) complete perforations.

The fractures of the skull due to shell fragments where the skull is either fissured, the bones depressed, or the calvarium extensively shattered, are somewhat similar to ordinary fractures by direct violence. In these cases the symptoms are usually those of concussion and compression, the injury to the brain being due only to the depressed or indriven bone fragments. In fractures of the skull by bullet, when the bullet penetrates, there is, in addition to the injury and indriven bone fragments, the direct injury produced by the missile itself.

Gutter Fractures.—In a typical gutter fracture there are two apertures in the scalp, with a gutter plowed through the outer and inner tables of the skull. The inner table, which forms to greater or less extent the floor of the gutter, is usually extensively comminuted, with inward, downward, or outward displacement of the fragments. The length of the gutter usually depends upon the degree of curvature of the surface of the skull at the place struck. In the more superficial gutter fractures there may be but one opening in the scalp, the scalp wound and outer table of the skull forming the gutter and the inner table forming its floor. Even in these

cases the inner table is ordinarily shattered to a considerable extent and particles of bone are driven downward into the brain.

The mortality from gutter fractures in the Boer War was 21.6 per cent.

Penetrating Gunshot Fractures of the Skull.—In these cases the missile, whether rifle bullet, shrapnel, or fragment of shell, penetrates the cranial cavity without passing through. The missile may lodge in the brain, in the entrance wound, or may glance off. The character of the skull injury will depend most largely upon the velocity of the missile, and the injury to the brain will depend upon this point, together with the extent of penetration. If the fracture be by a bullet at moderate velocity, the entrance wound will be small and the bullet will pass into the brain, producing a minimum amount of injury in the cranial cavity. If infection does not follow, the bullet may become encysted and give rise to little after-disturbance.

Perforating Gunshot Fractures of the Skull.—The number of cases in which the missile goes completely through the skull has been greatly increased with the use of the small-caliber, jacketed projectile. When this missile is at moderate velocity, as before stated, it may pass completely through the brain and the amount of tissue destruction be almost entirely confined to the extent of its track. In these cases the immediate and later effects will depend very largely upon the region of the brain through which the missile has passed, and the presence or absence of infection. In the one hundred and thirty-three fractures reported in the Boer War, 45.8 per cent. were perforating, and of these 39.3 per cent. died. It appears in perforating fractures that recovery is decidedly more common in wounds of the frontal and upper parietal region, the mortality being much higher if the wound is in the temporoparietal or the occipital region.

Infection.—In cases of fracture involving the brain, next to the amount of brain destruction infection is the most important factor. In former wars a large majority of late deaths was due to intracranial infection. With modern methods such inflammation may be quite commonly confined within small compass unless the infection be very deeply seated, and this control of inflammatory action has undoubtedly materially reduced the mortality in wounds of the cranial region.

Treatment of Fractures of the Skull.—In the treatment of all fractures of the skull by war weapons it is to be borne in mind that there is almost invariably depression or displacement of fragments of the internal table, and that on account of the usually dirty condition of the scalp, most of these wounds are at least superficially infected. In fracture by undeformed jacketed bullets the infection may be confined entirely to the scalp wound and the deeper tissues escape. The fact that the inner table of the skull is almost always fractured and the fragments displaced establishes the principle that all skull fractures by war weapons should be carefully explored unless there is an entire absence of symptoms of intracranial injury or the conditions are such that the surgeon cannot do the operation aseptically. At advanced aid stations the usual treatment will be simply

the application of occlusive dressings, but, when the patient reaches the field hospital or other place where aseptic operation may be done, careful exploration of the fracture should be made. When the fracture is a penetrating one by a modern bullet, the brain tissue is pulpified, and the bone fragments pressing upon or driven into the disorganized and pulpified tissue can hardly produce much immediate trouble. The condition is quite different when large plates or fragments of bone are driven down into the brain or press upon it. These conditions demand more prompt relief. To explore the wound the scalp should be turned aside after incision through all its layers. The fragments can then be usually elevated without the use of a trephine, the aperture of entrance of the missile being sufficient to allow exploration or afford a starting-point for the use of rongeur forceps.

Shock is always a prominent symptom in gunshot fractures of the skull, and particularly so in cases of penetrating and perforating wounds, while concussion is rare unless the skull be struck by a large, slow-moving projectile, such as a fragment of shell.

Nearly all deaths which follow fractures of the skull by war weapons and in which the fatal termination is not due directly to the trauma, result from intracranial inflammatory processes arising from primary or secondary infection of the wound. This infective meningitis may be either local or general. If it be local, the prognosis is fairly favorable; if general, it invariably ends fatally. In many cases modern methods of cleanliness, drainage, and antisepsis will limit the inflammation to the neighborhood of the wound. When symptoms of inflammation appear, the wound should be carefully inspected under anesthesia, cleaned and drained, and necrosed bone, if found, should be removed.

Hernia cerebri and abscess of the brain are not uncommon complications. Loss of substance of the dura mater and infection are the principal causative factors of the former, and deep infection of the latter, condition. In the early treatment of skull wounds involving the dura the effort of the surgeon should be directed toward saving all of this membrane possible. When hernia cerebri has actually occurred, careful protection, cleanliness, mild antiseptics, cold, and moderate compression should be used. The use of absolute alcohol for painting over the surface of the growth has been recommended. When necessary, excision, cauterization or ligation, while dangerous, may be required.

Symptoms of traumatic abscess of the brain are usually very slow in appearing and often obscure. Headache of varying degree, irritability of temper, drowsiness, twitching of certain muscles, Jacksonian seizures, subnormal temperature or only a slight rise, and slow pulse are common. The treatment is usually somewhat easier than in the case of idiopathic abscess, for the track of the wound usually gives a line along which exploration may be made.

Wounds of the Face.—Because of the exposed position of the face, wounds of this region are comparatively common, and are often serious, in that they may produce marked deformity, loss of vision through involvement of the eyes, or impairment of the masticating function through

destruction of the upper or lower jaw or damage to the maxillary articulation. The character of the trauma necessarily depends largely upon the weapon or missile by which it is produced. Hand weapons ordinarily give deep, incised wounds which may bleed profusely and require arterial ligation. Deformed bullets and fragments of shell, unless the fragments be very small, generally cause extensive and disfiguring injuries. Wounds by undeformed, small-caliber missiles generally produce a minimum amount of trauma and may not cause much damage unless they involve the orbit or strike the lower jaw. The central part of the face has been traversed in all directions by undeformed bullets, the destruction done by the missile being confined to its track and recovery resulting with practically no disfiguration. In wounds involving the lower jaw the form of fracture is considerably influenced by the velocity of the missile and by whether or not the teeth are struck. The osseous tissue of the lower jaw is comparatively compact and resistant, and, when the teeth are struck, they may act as secondary missiles, considerably enlarging the area of trauma. The later danger in wounds of the face mainly arises from the danger of infection on account of unclean nasal or buccal cavities. In seventeen cases of facial wounds by gunshot in the Spanish-American War three died, all the result of septicemia.

Treatment.—The treatment of wounds of the face must be directed toward the control of infection and the prevention or repair of possible deformity. Mild antiseptic nasal douches and mouth-washes in wounds involving these cavities are all that are usually required in wounds by undeformed bullets. In fractures of the upper and lower jaw, replacement and wiring of the fragments may be required, together with subsequent dental restitution, and, in cases of extensive disfiguration by shell fragments, plastic operations can frequently be successfully done.

Wounds of the Eye.—All varieties of injury to the eye are observed in war, from simple contusions up to complete destruction of the eyeball or injury to the optic nerve or vessels supplying the eye by bullets passing behind the orbit. Transverse and oblique shots which injure the eye invariably produce wounds of the surrounding parts, and in some cases both eyes may be injured by the same missile. Vertical and transverse shots may pass behind the globe and sever the optic nerve or so damage it as to cause complete blindness. It should not be forgotten that sometimes such a transverse shot may also involve the brain by injury to the roof of the orbit.

In wounds of the eye in which the eyeball is materially damaged prompt enucleation is the best treatment. When the eye is injured by very small missiles or particles of metal which penetrate the eye, expectant treatment may be adopted, but in such case the eye should be closely watched for inflammatory symptoms and for sympathetic inflammation in the uninjured eye.

Wounds of the Neck.—So many important structures are closely packed in this region that wounds of the neck are generally of serious import. At the same time it presents some remarkable and almost inex-

plicable cases of escape from serious injury. This region has been traversed in almost every direction and in such lines that it appears anatomically impossible for the structures to have escaped, and yet they have done so. As a result of observation of such cases in the Boer War, Stevenson has come to the conclusion that the important vessels and nerves in the neck may slip aside and allow a small-caliber missile to pass through without injuring them.

The conditions following gunshot wounds of the neck which generally call for attention are aneurism, aneurismal varix, injury to some of the large nerves, and wounds of the trachea, larynx, or esophagus.

Post-traumatic aneurism or aneurismal varix in the neck is not uncommon, and these sequelæ have to be treated along the usual lines. Wounds of the main nerves in the neck are always serious, for the reason that repair is generally impossible.

Wounds of the trachea or larynx are immediately dangerous through the possibility of suffocation from inflow of blood into the air-passages or the rapid onset of edema. Secondarily, septic bronchitis or pneumonia is the usual cause of trouble. The treatment of wounds of the trachea and larynx which has been most successful is immediate tracheotomy. The cases so treated by Haga in the Japan-China War and by the medical officers in the Anglo-Boer War have established the value of this procedure.

Wounds of the esophagus are of serious moment, both from interference with nutrition and from their extreme liability to produce deep suppurative conditions in the neck with consequent septicemia. The treatment of wounds of the esophagus is operative interference as soon as possible. Incision should be made down to the esophagus, the wound repaired if possible, or, if this cannot be done, efficient drainage down to the site of the injury in the esophagus provided. This will serve to prevent deep-seated infection from traveling along the lines of the fascias. The patient may be fed by rectum, by the stomach-tube, or, if necessary, through a gastrostomy opening.

Wounds of the Spine and Spinal Cord.—Wounds of this region by hand weapons are rare. Wounds by gunshot, especially those which involve the spinal cord, are always of very serious import. In recent wars the frequency of wounds involving either the spine or spinal cord appears to have somewhat increased. In the American Civil War about one-fourth of one per cent. of all wounds were wounds of this region. In the Spanish-American War and the Philippine insurrection this proportion was more than doubled. The increase in frequency of fracture of the spine with or without involvement of the spinal cord is probably due to the greater penetrating power of the modern bullet. With the older missiles not only did the bullets not penetrate so deeply into the tissues, but they were frequently arrested by the resistant structures about the spine or by the vertebræ.

The mortality in recent wars is high, higher even than with the older missiles, this probably being due to the fact just named, *i. e.*, that the modern bullet is more likely to pass through the vertebræ and so reach

the cord. In the Civil War 55.5 per cent. of all spinal fractures ended fatally. In the Spanish-American War the mortality was as high as 66.6 per cent., and in the Anglo-Boer War the mortality in forty-eight cases was 58.3 per cent. Infection enters as an important factor, especially in cases which terminate fatally. When infection occurs, the resulting meningeal inflammation is even more apt to end in death than is similar involvement of the intracranial structures.

Fractures of the spine without involvement of the cord are usually due to slow-moving missiles or to missiles which strike the vertebræ at some distance from the cord. Cases of fracture without involvement of the cord, when uninfected, rarely lead to serious results unless they are complicated by wounding of one of the larger vessels of the cord or of the nerve-roots. Fractures of the processes and centra may readily occur without involvement of the cord, but fracture of the arches is usually accompanied by injury to the cord. Fractures of the centra are usually in the nature of fairly clean-cut perforations, but other parts of the vertebræ when struck are usually considerably shattered.

The symptoms of fracture of the spine without lesion of the cord differ according to the location of the injury and whether or not there is temporary injury to the cord. Local pain, tenderness, mobility, and crepitus may be determined in fracture of the processes, but more often the injury in indicated rather by the course of the missile or by symptoms of concussion of the spine or injury to the nerves. The shock of impact in gunshot cases is usually sufficient to jar the cord severely and cause a more or less transient spinal concussion, while injury to the nerves is manifested by suspension of or interference with their functions.

In involvement of the cord, the cord may be concussed, compressed, or entirely destroyed. Concussion, unless it is severe, is usually more or less rapidly recovered from, but where the cord is compressed, or is partly or wholly destroyed, the injury assumes a very serious character. Degenerative changes often go on with astonishing rapidity, together with the formation of deep sloughing bedsores and cystitis. The surgeons in the Boer War spoke particularly of the painful and distressing features in these cases, and state that no cases in the hospital seemed more hopeless or more distressing.

Concussion of the spinal cord by gunshot is due to the shock of impact of the missile or the molecular vibrations set up by the passage of a missile at high velocity near the cord. The effect of such injury may be transitory pain and loss of muscular control or complete paralysis and anesthesia with persistent pain and general neurasthenic symptoms.

Compression of the cord may be due to hemorrhage, to depressed fragments of bone, or to pressure from a lodged missile. Unless the compression of the cord is great, complete distal suspension of the function of the cord does not occur, but these cases are so apt to be complicated by partial destruction of the substance of the cord or pronounced concussion that they are difficult to diagnose.

Destruction of the cord may arise either as a result of direct injury by the bullet or indriven bone fragments, or may occur as the result of the

transmission of energy from a missile at high velocity passing near the cord. This shattering of the cord by molecular vibration has been noted by all observers as a result of the use of the modern high-velocity projectile. It has occurred in cases where the bullet barely grazed the membranes of the cord. The cord is reduced for some extent to a custard-like material and is as completely and permanently destroyed as though it had been severed by a missile.

In cases of involvement of the cord the determination of the exact condition is often difficult, and early in the case it may be impossible. Shock is usually marked, and paralysis and anesthesia of the parts supplied from the cord below the injury, paralysis of the bladder and rectum, and loss of reflexes commonly occur at once, whether the injury is a complete destruction of the cord or not. If these be due to concussion only, they may disappear, but if they persist the case must be considered one of serious cord involvement. The complications and sequelæ following injury to the cord are spinal meningitis, myelitis, diseases of the kidney, and bedsores. Meningitis and myelitis are usually due to direct infection. They may be either local or general. The general form is quickly fatal. In the degenerative changes which follow injury without infection, the course of the case is slower, but the patients usually eventually die from the conditions connected with cystitis, renal disease, and decubitus.

The *treatment* of gunshot fracture of the spine is always difficult unless the case be one of those simpler forms of fracture without involvement of the cord or injury to the nerves. The great majority of spinal wounds are made by bullets and are deep and small, making the determination of the amount of injury to the cord very difficult. If the bullet has passed through, some opinion may be formed from its course, but if the bullet is lodged no such information is possible. The depth at which the cord is placed, the size of the operation required to disclose it, and the fatal effects which follow infection of the meninges, have all to be considered, and make exploratory or reparative operations possible only in the hospitals, where aseptic technic can be employed and where the necessary time for the operation can be given. As a result, in military surgery the immediate treatment of wounds of the spine must be expectant. A primary dressing should be applied and the patient handled as carefully as possible. When the case reaches a suitable hospital, if there is a lodged missile the *x*-rays should be employed, and an exploratory laminectomy may be done. In wounds of the spine by shell fragments and in all infected cases exploration of the wound, followed by thorough antisepsis and drainage, should be instituted as soon as possible.

Wounds of the Chest.—Wounds of the chest naturally divide themselves into penetrating and non-penetrating wounds. There is nothing special in the treatment of non-penetrating wounds of this region, but penetrating wounds require particular consideration on account of the peculiarities of the intrathoracic structures. The wide difference in structure and function of the different viscera contained in this body-region produce wide variations in effect following their injury.

The mortality in penetrating wounds of the chest in cases coming under treatment has been greatly decreased in recent wars.

MORTALITY OF PENETRATING WOUNDS OF THE CHEST.

	Per Cent.
English in Crimea	79.2
American Civil War, U. S. Troops	62.6
Franco-Prussian War, Germans	56.7
Spanish-American War, U. S. Regulars	24.5
Boer War, British	14.0

Fifty-eight cases of penetrating wound of the chest were reported in the Spanish-American War, with thirteen deaths. For the Boer War, Stevenson reports two hundred and fourteen cases with thirty deaths. This latter is a very low mortality, and, compared with the high mortality of the Civil War and preceding wars, shows a most marked reduction. A large part of this reduction is due to the fact that the small-caliber rifle bullet can pass through the lungs with the production of a minimum amount of trauma and without infecting them or the pleura. Another factor is that, probing and exploration of the wounds having been discontinued, infection of the pleura is in many cases avoided.

Penetrating wounds of the mid-region of the chest are usually immediately fatal from injury to the heart and great vessels, but some cases come under treatment in which it appears that the heart may have been struck or the pericardium entered without fatal result. Wounds of the lateral regions which involve either the pleura or lung are of much less serious moment, although a fair percentage of these cases present subsequent complications or sequelæ, such as hemorrhage or empyema. Penetrating wounds by shell fragments are of more serious import than similar wounds by bullets, unless the bullets be deformed. The large and jagged opening torn in the chest wall may lead to immediate collapse of the lung, and the injury is quite surely followed by sepsis if death does not immediately occur.

In wounds of the lungs by undeformed bullets the minimum of trauma is produced, for the structure of these organs is so loose that a bullet in passing through them produces destruction of tissue only in the line of its track.

The probable proportion of infection which may be expected in penetrating wounds of the chest may be inferred from the results in the Boer War, where in two hundred and fourteen cases, thirty-two (about 15 per cent.) were followed by pyothorax. Stevenson states that the wounds made by ricochet bullets, by bullets of large caliber, and by shell fragments were usually septic, and that bullets which had passed through infected areas before entering the lungs produced infection. He cites a case in which the bullet had traversed the ascending colon and liver, then passed into the right pleura and caused right empyema.

The symptoms of penetration in order of frequency are hemoptysis, dyspnea, pain, collapse and shock, severe cough, friction sounds, and deficient chest movement. The complications which may arise later are internal hemorrhage, pleurisy, empyema, and abscess of the lung.

Hemoptysis occurs in about one-half, dyspnea in about one-third, pain in about one-fourth, and collapse or shock and severe cough in about one-fifth of the cases. About one-fourth of the cases give evidence of intrapleural bleeding, about one-eighth have empyema, and about one-half have pleurisy. External hemorrhage is quite rare. Internal hemorrhage is evidenced by the constitutional symptoms and by the usual symptoms of hemothorax. Recurrent hemorrhage is usually accompanied by rise of temperature which may be mistaken for beginning empyema. Dyspnea and pain commonly go together; both vary greatly in severity and in many cases are entirely absent. Shock and collapse generally result from injury by a large missile, such as a fragment of shell or a deformed bullet; and in wounds from undeformed small-caliber bullets which merely traverse the pleura or lung, shock is commonly absent. In many cases of perforation of the chest by small-caliber bullets pain and other symptoms are but little pronounced, the position of the entrance and the exit wound alone giving evidence of the fact that the missile has traversed the chest cavity.

Treatment of Penetrating Wounds of the Chest.—The fact that so many penetrating wounds of the chest by small-caliber missiles give rise to only a few symptoms leads the patient, and often the surgeon, to concern himself too little about the condition. Patients with such wounds often walk about showing no evidence of serious injury, and consequently have taken it upon themselves, or have been allowed, to move about freely. All observers, however, note the greater frequency with which hemorrhage recurs or occurs later in those cases which are allowed to move about or who are jolted over rough roads or in conveyances without springs. Every penetrating wound of the chest should, therefore, be carefully watched and kept quiet for some time, even though the symptoms be slight. The chest should be immobilized by bandaging or by adhesive strips and the patient kept in a recumbent position. If there is evidence of internal hemorrhage, not only should the patient be kept quiet and the chest immobilized, but morphin should be administered in doses of considerable size. Should the intrapleural bleeding cease spontaneously, the patient should be kept quiet and no immediate attempt should be made to remove the blood unless it has accumulated to such an extent as seriously to impair respiration or press upon the heart. If the blood is removed too soon, the bleeding may commence again; hence it is better to wait until the serum has separated and remove this by aspiration. If the bleeding be from an intercostal artery, it should be ligated in the wound.

The military surgeon will rarely be able to do an intrathoracic operation for bleeding from the vessels of the lung, as operation requires such apparatus as the Fell-O'Dwyer apparatus or the pneumatic cabinet.

The possibility of the occurrence of *empyema* should always be borne in mind, and, should it occur, its early diagnosis is of great moment, and resection of a part of a rib and drainage should be at once instituted. Early recognition and operation will often prevent the great thickening of

the pleura which necessitates the more extended operations of Schede or Estlander.

When a bullet lodges in the chest wall, it usually causes little or no inconvenience, but when it produces symptoms which indicate its removal, it should be first localized by the *x*-rays to determine whether or not such removal is practicable. On account of the non-resistance of the lung, bullets rarely lodge in it, but rather pass through and fix themselves in the chest wall. In rare cases lodgment in the lung tissue itself may occur. Should this be the case, the missile usually becomes encysted and gives rise to no further trouble, although an abscess sometimes develops about it which may require evacuation.

Wounds of the Abdomen.—Wounds of this region have been of great interest to surgeons since modern surgical methods have allowed safe exploration of the abdominal cavity. The results of operative abdominal surgery in civil practice have, however, not been paralleled in military surgery. The civil surgeon is able to operate with every attention to aseptic detail, has plenty of time and, usually, numerous assistants. The circumstances in war are such that these conditions cannot be paralleled except in rare cases. The condition of the aid stations and advanced hospitals is usually such that aseptic work is impossible, the time to be given each case is short, and the number of assistants is small.

FIG. 506.—RUPTURE OF THE ILEUM IN TWO PLACES FROM A GRAZE BY A MAUSER BULLET.

Skin only abraded, not penetrated—the photograph exaggerates the injury to the skin (Stevenson: Report, South African War).

The results obtained in the treatment of these wounds in war rest more particularly upon the conditions incident to the wounds themselves. The patients who recover do so generally for the reason that the abdominal organs have not been seriously wounded, the intestines have not been perforated, and septic peritonitis has not been set up.

Non-penetrating wounds of the abdomen are rarely of serious import except in those comparatively rare cases where the impact of the missile against the abdominal wall has caused rupture of a viscus without penetration of the abdominal cavity. Such rupture of an intra-abdominal organ or of the intestine may be produced by the impact of a fragment of shell against the abdominal wall or even by a contusion by bullet. Stevenson reports a case of the latter sort in which a patient was struck by a Mauser bullet a little above the umbilicus in such oblique direction that the skin was only grazed. Peritonitis set in and the man died on the

seventh day. On autopsy two ruptures were found in the ileum immediately beneath the point of impact of the bullet.

In *penetrating wounds of the abdomen* so much depends upon infection or non-infection, and upon whether or not a viscus is wounded, and, if one is wounded, the particular one injured, that in considering these cases all these special facts must be borne in mind.

Penetrating Wounds of the Abdomen without Symptoms of Visceral Lesion.—The abdominal cavity has been traversed in almost every possible direction without any resulting symptoms of injury to intra-abdominal organs. That the organs have escaped in *all* these cases is impossible. Undoubtedly in some the liver, kidneys, and possibly the intestines, have been injured by a missile, but with no ill effect resulting. The small size of the modern military rifle bullet largely accounts for such cases. If large blood-vessels of intra-abdominal organs are not cut, the hemorrhage may be moderate and the patient recover without marked symptoms. If the bullet wounds an empty intestine, it is quite possible that nature may repair the injury. In fact, it has been noted that in some cases openings in the intestine made by small-caliber missiles have been closed either by the intestine fixing itself to the adjoining gut or by a piece of omentum falling over the aperture and sealing it. Necessarily these cases are rare, but they undoubtedly occur and account for some of the recoveries. If the wound be infected from without, as may sometimes be the case, even though a viscus be not wounded, the patient will necessarily suffer from septic peritonitis, and unless the sepsis can be controlled by operation, cleaning, and drainage, the case will likely end fatally.

Wounds of the Stomach.—The surgeons in the Boer War have reported a number of cases of alleged wounds of the stomach in which recovery has followed without operation. In some of the cases so reported it is quite possible that the stomach was not really injured, but in others it undoubtedly was. In Stevenson's report nineteen cases of wounds of the stomach are given. Of these but two died, one from peritonitis after operation. It seems evident, as Stevenson remarks, that bullet perforations of the stomach by small-caliber missiles are not as fatal injuries as are those produced by the older bullets.

Wounds of the Small Intestine.—Wounds of the small intestine are much more serious than are wounds of the stomach. In the American Civil War every case in which the small intestine was known to have been wounded died. In late wars there is a considerable percentage of recoveries. In the Boer War thirty-five cases were reported in which the small intestine alone was wounded, and of these twenty-two, or 62.8 per cent., died. The fact that one-third of the cases recovered is evidence that nature may be relied upon to a certain extent; and when one considers the extreme danger from peritonitis following such injury, the fact that so many recoveries occurred is surprising. In the thirty-five cases referred to, laparotomy was done in eleven, and of these seven died. The surgeons in the Boer War all report themselves as convinced that operation is justifiable only when aseptic technic can be employed or when the patient would unquestionably die if operation were not done.

Wounds of the Large Intestine.—These are not nearly so serious as are wounds of the small gut. In forty-seven cases reported in the Boer War thirteen died, a mortality of 27.7 per cent. As the large intestine is not entirely covered by a peritoneal coat, it can be readily wounded extraperitoneally, but the probabilities of fatal termination appear to be equal whether the intestine is wounded intraperitoneally or extraperitoneally. An extraperitoneal wound almost invariably results in fecal cellulitis which goes on to suppuration or septicemia. Wounds of the rectum appear to be equal in gravity to other wounds of the large intestine. In the Boer War the mortality of wounds of the rectum was 30.7 per cent., deaths being due to peritonitis, internal hemorrhage, and septicemia.

Wounds of the Bladder.—These appear to be of about equal gravity with wounds of the large intestine, for in twelve cases reported from the Boer War four, or 33 per cent., died. As with the large intestine, the danger appears to be equally great, if not greater, from extraperitoneal and from intraperitoneal wounds, the resulting cellulitis and septicemia accounting for the mortality.

Diagnosis of Intra-abdominal Injury.—The determination of the exact character of intra-abdominal injury after gunshot is nearly always difficult, and often impossible unless resort to laparotomy is had. In general, however, it may be stated that the symptoms of the condition are more or less closely related to the gravity of the injury. In cases which are not operated upon and recover, it has been noted that the shock is usually moderate, evidence of internal hemorrhage is slight, abdominal tenderness is localized, the pulse goes little above 100, and there is but moderate elevation of temperature. When internal hemorrhage is pronounced, it is evidenced by the general symptoms of loss of blood, and, when the case develops septic peritonitis, the usual symptoms of this condition will appear. It is commonly known that very serious wounds of the intestine may occur and yet no evidence appear early in the case. But continued mild symptoms point indisputably to the fact that the intra-abdominal injury is not great or that nature has provided a cure.

Treatment.—The treatment of penetrating wounds of the abdomen must depend entirely upon the conditions. There can be no exception to the general rule that, given aseptic control, surgical skill, and sufficient time, there should be no delay in doing a laparotomy. Under these conditions there is practically no danger in the operation and it affords the only means by which the surgeon can determine early the exact intra-abdominal condition and repair it. Unfortunately, in the surgery of war, these favorable conditions are rarely present, and it is the absence of them, together with the fact that operation under sepsis is more surely fatal than non-interference, that makes the usual treatment of penetrating wounds of the abdomen in war differ from the treatment of similar wounds in peace. The theoretically perfect course is to operate immediately, aseptically, and properly, but operation without aseptic control is not permissible in any case unless the patient will manifestly die if no operation be done.

In military surgery, in addition to the frequent inability to insure

aseptic technic, the surgeon has further to consider the after-treatment of the case and the transportation which the wounded man must generally and necessarily undergo. Rest and proper diet are very essential post-operative factors in abdominal work. Both of these are often difficult or impossible of attainment under the conditions which obtain in war, and these, together with the time which often elapses between the receipt of injury and the time when operation can be done, are strong factors in determining what course the surgeon must pursue.

Exploration of the wound, even aseptically, to determine the question of penetration, is absolutely contraindicated; for if the surgeon finds that the wound passes into the abdomen, he must then do a laparotomy, and if he is unable to enter the abdominal cavity through the wound, the failure is no evidence that the penetration has not occurred.

The time of operation is of moment, for the earlier the operation is done, the easier it will be for the surgeon to prevent or check peritonitis from extravasation of intestinal contents. Unfortunately in war operation can usually be done only at a late period, some time elapsing between the receipt of the wound and the arrival of the patient at a field hospital where even an ordinary degree of asepsis can be observed.

In cases of dangerous internal hemorrhage where the surgeon has time and opportunity to operate, operation is sometimes justifiable, even without absolutely aseptic technic, when it is a choice between this and the early death of the patient; and the surgeon may be able to control the resulting peritonitis by leaving a large gauze drain in the abdomen. In extraperitoneal wounds of the small intestine and bladder, early exploration and free drainage are required to prevent the resulting cellulitis and septicemia.

Wounds of the Genital Organs.—Wounds of this class are comparatively infrequent and generally are not of serious moment. In gunshot wounds much depends upon the kind of missile by which the injury is produced, extensive lacerations being produced by fragments of shell, but with bullets the trauma is usually limited to the course of the projectile. When the testicle is traversed by the modern small-caliber missile, there is no general disorganization of its structure. Such cases are frequently uninfected and recover without any apparent impairment of function.

Wounds of the urethra are sometimes serious, but ordinarily they are readily managed. In the majority of cases a catheter can be introduced into the bladder without trouble, the injury usually being confined to the sides of the urethra and not being of the jagged, lacerated type commonly met with in civil practice. In the treatment of these cases the main points are the control of hemorrhage, the limitation of extravasation, and repair of the urethra. Where a catheter can be introduced into the bladder and there is no sign of extravasation of urine, nothing more need be done except carefully to watch the case for the onset of extravasation. Should it occur, a perineal section should be done at the site of the laceration, the wound thoroughly cleaned and a catheter introduced. If possible, the urethra should be repaired by suture and a catheter left in for a week.

When cellulitis from extravasation occurs, it must be treated by free incisions wherever signs of its presence appear.

Wounds of the Extremities.—About 70 per cent. of wounds in war are of the upper and lower extremities, the proportion being about equally divided between the two. About one-third of all these wounds are complicated by fracture of the bones.

The mortality in wounds of the upper and lower extremities is low, especially since modern surgical methods have been introduced. The mortality from flesh wounds is very low indeed, most of the deaths arising from cases in which the bones have been fractured. The great reduction in mortality in wounds of the extremities in modern wars is shown by the figures of the Spanish-American War as compared with those of the Civil War. In the American Civil War the mortality in gunshot injuries of the upper extremities was 6.5 per cent. In the Spanish-American War the mortality was but 0.2 per cent. In wounds of the lower extremity in the Civil War 13.8 per cent. died, and in the Spanish-American War 1.68 per cent. In the Boer War, in one hundred and forty-three cases of fracture of the upper extremities, three, or 2.1 per cent., died; and in three hundred and seven cases of fracture of the lower extremity, thirty-nine, or 12.7 per cent., died. As in the Spanish-American War, nearly all flesh wounds recovered. As might be expected, the highest mortality was in fractures of the larger bones, such as the femur and both bones of the leg. In one hundred cases of compound fractures of the arm, forearm, thigh, or leg in the Spanish-American War, thirteen amputations were done, or 13 per cent. In four hundred and fifty cases of the same sort in the Anglo-Boer War, ninety-seven amputations were done, or 21.5 per cent. In the thirteen amputations in the Spanish-American War, five, or 38.4 per cent., died, and in the ninety-seven cases in the Boer War, thirty-four, or 35 per cent., died. The comparatively high mortality after amputation is undoubtedly due to the great severity of the cases which require this procedure.

General Treatment of Wounds of the Extremities.—The usual treatment of wounds of the extremities is conservative. At the first lines of assistance suitable dressings and immobilization of the limb and, later, careful observation to determine whether or not infection has occurred, is to be practised. If infection is present but is in moderate degree, it can usually be controlled by carefully cleaning out the wound and the after-use of drainage and irrigation. Exploration of the fracture may be required when bone fragments are so displaced that they are pressing upon important structures or may later interfere with the function of the part.

When operative measures have to be adopted, the question of excision or amputation will arise. Excision in the continuity of the long bones has been unfavorably looked upon by military surgeons in the past. In pre-aseptic days the mortality from this operation was greater than from amputation, and the function of the limb following excision was, as a rule, not good. As these results were noted in wars previous to the adoption of modern surgical methods, it is quite possible that with the resources of asepsis and antisepsis limbs may be saved in the future by

recourse to excision with much greater probability of restoration of function and less danger to the life of the patient than in the past.

The mortality in amputations as shown above is still high, but, as noted, is undoubtedly due in large measure to the fact that these operations are done only in the worst cases. Amputation will have to be considered when the soft parts are greatly destroyed, when the main vessels of the extremity are severed, and when infection is present and cannot be controlled.

In **wounds of the upper extremity** every possible effort should be made to save the limb. The loss of a lower extremity can be fairly well compensated by an artificial limb, but no appliance has ever been devised which is even a fair substitute for a hand and arm. Fortunately the upper extremity, on account of the free anastomosis of the blood-vessels and the comparatively large blood-supply, is quite suitable for conservative treatment.

Wounds of the shoulder-joint have to be treated according to the conditions present. When the capsule of the joint alone is injured, occlusive dressing and immobilization of the limb will usually be all that is required. When the bones of the joint are so shattered as to insure resulting ankylosis, the joint should be explored under asepsis, loose fragments removed, and undetached fragments wired. Should this fail, an excision may be done later to produce a movable joint. Amputation will be rarely required except where there is extensive destruction of the soft parts, or where gangrene or extensive inflammatory reaction occurs on the distal side of the injury.

Gunshot fractures of the humerus will rarely require other than conservative treatment except under the conditions already given. If formal or informal excision has to be done, a very useful limb may result even though the humerus be considerably shortened.

Wounds of the elbow-joint should be treated on the same lines as are those of the shoulder. On account of the close articulation of the bones of this joint, injury to them is almost sure to be followed by more or less ankylosis, but some pronation and supination may be retained when the head of the radius has escaped injury. When the joint is not infected, passive motion should be instituted as early as would be done in a simple fracture. If the joint be infected, the best result that can be hoped for is the healing of the limb with ankylosis. The forearm should be flexed at about 75 degrees if ankylosis is expected. Excision of the elbow was not highly esteemed in pre-antiseptic days, but with modern methods the possibilities of this operation have been very greatly increased, and it is now a thoroughly accepted method of procedure.

In *fractures of the forearm* great attention should be given to the possibility of interference with pronation and supination through fragments extending from the radius to the ulna or the two bones being pressed together. If there are any fragments in the interosseous space, these should be removed and interosseous pads and splints should be so applied as to keep the bones apart.

In *gunshot wounds of the wrist* there is practically invariably resulting

disability. The size of the wrist bones relative to that of the missile is such that it is impossible for a projectile to traverse the wrist without comminution of the bones to a considerable degree, and bony necrosis is almost sure to follow such injury. This being the case, these fractures should always be examined when practicable by the *x*-ray, and, if conditions permit, the wound should be explored, all loose fragments of bone removed, and the joint put in the best possible condition.

Wounds of the Lower Extremities.—The treatment of wounds of the lower extremity is somewhat different from that of the upper, in that this part, if lost, can be better compensated for by the use of an artificial limb than can the upper extremity. Also, the lower extremity does not yield itself as well to conservative treatment where the bones have been shattered and the wound infected, or where the large vessels have been torn or large portions of the soft parts carried away. The blood-supply to the part is not so great as in the upper extremity and the possibility of gangrene and severe inflammation resulting when the vascular supply is partly interfered with is much greater in the lower than in the upper limb.

In *wounds of the hip-joint* expectant treatment is particularly to be recommended in military surgery unless the wound is large and manifestly infected. If the wound is infected, early exploration is required, followed by thorough drainage and irrigation, for in this way only can the very disastrous inflammation of the hip-joint be prevented or controlled. When infection is not present, non-interference will often give excellent results, but secondary operative measures may be required to relieve necrosis or troubles of the joint. When control of sepsis is possible and interference is required, the procedure should be, first, exploration of the joint; second, removal of loose bone fragments; and, third, immobilization and extension of the limb. When the wound is infected and the head of the femur is badly shattered, conservative treatment will probably be followed by inflammation of the bone and surrounding tissues which will be difficult, if not impossible, to control. In such cases the surgeon should make a clean excision of the head of the femur and institute thorough drainage, and, if this does not answer, amputation must be resorted to.

Amputation at the hip-joint as an immediate operation will be required only in cases in which there is an extensive destruction in the soft parts about the joint or below it. The mortality from disarticulation of the hip is great. In eighty-two primary amputations in the Civil War the mortality was 91.4 per cent. In the Spanish-American War there were three disarticulations with one death. In the Boer War there were twelve operations with eight deaths, a mortality of 66.7 per cent. This operation, therefore, is justified only in extreme cases.

Wounds of the femur, knee, and ankle-joint require only the same general treatment as has already been indicated. As a rule, excisions in the lower extremity are not as favorable as are similar operations in the upper. The limb as shortened by such operation is usually not as satisfactory as an artificial appliance, and where much of the continuity of the bone or a joint has to be removed, better results can usually be obtained by amputation than by excision. This is especially so when

the number of fragments of bone is great, infection is present, the soft parts much destroyed, or the vascular supply materially interfered with.

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CHAPTER LXVII.

NAVAL SURGERY.

By Surgeon-General P. M. Rixey, U. S. Navy,

WASHINGTON, D. C.

Definition.—Naval surgery is to be defined as that branch of general surgery which has to do with the wounds and injuries and surgical conditions peculiar to life on ships of war and their activities in battle. Thus expressed, the subject must differ from military surgery, which deals only with conditions resulting from hostilities on shore. It is, however, not to be inferred that there is a distinct line drawn between the two, for naval surgical experience, under certain circumstances of service, extends well into the territory of small-arm injuries and partakes of the surgery peculiar to the army. The naval forces, comprised of officers and enlisted men of the navy and marine corps, also may be called upon to serve on shore in any part of the world; and when so employed, the influences to which they become exposed, and the peculiar surgical conditions resulting, are practically the same as those of the army in the field.[1]

While, therefore, naval surgery embraces in general much that would pertain to military surgery, it has a domain peculiar to itself and is entitled to special treatment. This truth finds explanation in the inseparable features of environment on board a modern vessel, which furnish a distinct and unique set of surgical cases, and in the fact that most of the wounds are caused by shells or the flying fragments of steel and iron and the splinters of diverse materials resulting from their explosion. If, however, the word "military" is construed as referring, in this connection, to surgery due to conditions produced by war, including hostilities ashore and afloat, then naval surgery becomes a part of military surgery and relates to all surgical conditions that are peculiar to naval action or to life aboard men-of-war. The latter view is considered to be the one sanctioned by custom and usage of the present day.

The subject will be considered under the following heads: (1) Historical. (2) Battleship conditions of the present day. (3) Organization of the medical department and preparation for battle. (4) Conduct of the medical department during battle. (5) Surgical conditions of naval warfare. (6) Conduct of the medical department after battle. (7) Methods of transportation. (8) Hospital ships.

HISTORY.

The appointment of surgeons to ships may be properly credited to that period when, in consequence of the jealousy of European nations with respect to their commerce and colonial possessions, warlike disputes at sea became frequent between them.[2] The improvement in naval tactics; the increased size and more complicated construction of ships; and the

greater length of the voyages, as compared with ancient and medieval times, also played an important part in pointing out the desirability—indeed, the necessity—of creating this new field for surgical practice. As regards the history of naval surgery in the United States,[3] it is interesting to note that it had its origin in Virginia, in natural consequence of that colony's naval preparation for the anticipated struggle with the mother country.

It is a far cry from early conditions to the present splendid advance of medical science and its mode of application to the naval service, and it is pathetic to contemplate the conditions which then prevailed and with which early naval surgeons contended. The status of the medical department was most equivocal; its accommodations a concession, a courtesy, a makeshift; and its equipment meager—provided by the surgeons themselves, so that it may be readily understood that the character and quality varied materially.[4]

From these early primitive provisions for the bare necessities in accommodations and supplies for the sick and woundeb, and the humiliating position of the ship's surgeon, the change has been evolved. The improvement in the art of war on land produced equal progress in the art of destruction at sea, and the necessity for the attendance of surgeons has advanced in proportion. The naval surgeon has become an indispensable factor on board ship; and naval surgery as important a field of work at sea as military surgery by land. The process of evolution has been slow and not uninterrupted, but gradually the regular establishment of a medical department in naval organization became an accomplished fact, and now, in most navies, it exists and functionates under one head, and the provisions for the sick and injured conform in every detail to the most modern ideas of the medical profession.

BATTLESHIP CONDITIONS OF THE PRESENT DAY.

Personnel and Features of Man-of-war Life.—It would be difficult to imagine a community in which ample facilities for the care of emergency cases is more urgently needed than on a modern man-of-war. Perhaps nowhere in the world are surgical injuries so likely to occur, and the acute surgical conditions which fall to the lot of the naval surgeon are many and varied both in type and degree.

In Peace.—The personnel of a modern battleship can no longer be collectively termed "seamen." The extensive and complicated machinery to be handled demands the selection of men of varied special training, representing a large number of trades and arts, and the whole ship's complement taken together is comparable to the working part of the population of a small, active, manufacturing town.[5]

Aside from the inseparable dangers of these diverse occupations,—carpenters, blacksmiths, electricians, coal-heavers, firemen, machinists, gunners, etc.,—each class of men, such as the engineer force (than which none leads a harder life), is exposed to special dangers, and if we add the duties and conditions of life at sea common to all, it becomes a matter for remark,

not that accidents are common, but that they are not more frequent. A warship of today is a vibrating, busy, steel citadel, fairly alive with humanity, surrounded by complex mechanical devices and other dangers that are a constant menace to life and limb.[6] The injuries to which man-of-war men are exposed are of a very special character, like their surgical maladies, but accidents occurring in the performance of their duties have changed their nature and relative frequency owing to the transformation in our ships of war.

Formerly, the greatest number of accidents were due to handling sails and ropes and their management under way, which necessitated going aloft. These conditions and the liability to certain accidents which they impose still exist on some of our training ships, but in the main the exposure to accident is very different, as may be imagined by those who are familiar with the extreme complication of our ships, in both construction and equipment.[7] The officers and men live and move and have their being among the most powerful explosives, machinery, and a multitude of other imminent possibilities of accident. They are exposed to the hazards of unusual occupation—hoisting and lowering boats and ammunition, revolving massive turrets, taking on stores by heavy swinging booms, coaling ship, attending to the chains by which the anchors are dropped and weighed, running up and down narrow passages or going to and fro by day and night on slippery decks when the ship's motion requires constant support in moving about, and frequent handling and exercising with rifles and guns. From all these conditions it is readily seen how great is the liability to the most serious injury, internal and external, and the records are filled with incidents attesting its actuality. The whole category of injuries, varying in character from slight contusions to complete destruction of the body, may be found in the annals of naval surgical experience. Space does not permit their enumeration, but the recitation of a few recent representative casualties will suffice to illustrate the widely dissimilar nature of causes and effects.

"A lacerated wound (amputation) caused by a shark's bite, the thigh having been grasped four inches above the knce-joint, stripped down to the bone, and torn away at the joint, leaving the lower end of the femur bare. The patient recovered after a circular amputation."

"Two cases of gunshot wound of the leg from men dropping loaded revolvers on the deck, the men carrying them being themselves the victims."

"On the 'Manila' during target practice three men were injured by the explosion of a Colt automatic gun. They were standing at the time five or six feet away from the breech, in the rear and to the right. The explosion was due to the jamming of a cartridge in the muzzle."

"On one of the small gunboats in the Philippines a cook was leaning over the rail watching the disembarkation of some soldiers when the Krag rifle of one of them went off. The projectile struck an iron plate and disintegrated, one fragment entering and destroying the right eye, which was subsequently enucleated; another injuring the common femoral, resulting in aneurism."

"On the U. S. S. 'Massachusetts,' December 15, 1905, the gasket of a boiler manhole plate blew out. Four persons were so scalded as to require transfer to hospital, while three others lost their lives. Of the seven persons involved in the accident, four were imprisoned in the fireroom through the closing of the door by the jet of steam and water behind it. After a half hour's confinement one of these men, who had thrust his head into a coal bunker, managed to effect his escape, and though severely injured made a satisfactory recovery. Of the three remaining

victims, one was found dying and two dead when, about an hour and a quarter after the accident, it was possible to enter the fireroom."

"On April 13, 1906, while the U. S. S. 'Kearsarge' was engaged in target practice with the fleet off Cape Cruz, Cuba, the accidental ignition of three sections of the powder charge of a 13-inch gun in the forward turret resulted in the grave injury from burns, external and internal, of the entire personnel of the turret, comprising two officers and twelve men. Early on the following day the two officers succumbed to the injuries. Five of the injured men died before 10 P. M. of the day of the accident, three died subsequently, and four recovered."

In War.—The conditions that prevail daily in time of peace are aggravated a hundredfold during an engagement. Then the hurry and excitement, and dangers incident to handling explosives and ammunition, and the firing of various weapons of war under the stress of nervous unbalance and tension, to say nothing of the countless dangers imposed by the enemy, multiply the chances of injury innumerably.[8]

Medical Department.—Out of these ever-increasing dangers to life and limb and general health, coupled with the growing realization of the economic importance of attention to the physical welfare, came the convincing, impelling argument for the betterment of the medical department. To every one acquainted in the slightest degree with the nature and duties of a ship of war, health means power; without it no ship and no fleet can be efficient; and what are ships, what are fleets built after the most approved models, guns cast on the most improved pattern and caliber, crews trained to the point of highest efficiency, if there is physical incapacity.[9] It is obvious that generous provision had to be made for the sick and injured that would conform to modern ideas.

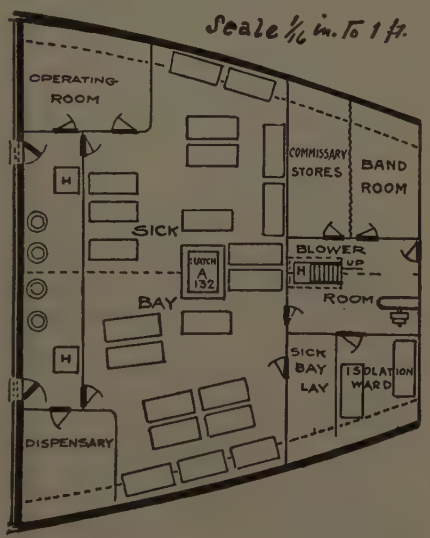

FIG. 507.—DECK PLAN OF SICK QUARTERS, U. S. S. "CONNECTICUT."

It is not enough that medical and surgical dispensary service be provided, for it is not always possible to transfer the seriously sick or those needing operation, and a ship's radius of utility would inevitably be impaired by any avoidable and undue reliance upon relief from outside sources. This desirable and necessary independence of a man-of-war demanded an ability properly and, if need be, finally to care for both medical and surgical disabilities. The time is past when it is necessary to combat the old prejudice that on a vessel of war all should be sacrificed to the exigencies of battle. Now we understand that there are other exigencies equally legitimate which can be very well reconciled with the first, and it is right to recognize that they are today a large part.[10]

Provisions for the Sick and Injured.—The real ships are the armored

cruisers and battleships, and it is to these that we will limit our study in regard to the sick quarters. Old ships are rarely called to take part; their rôle is effaced, like the smaller ships, which need not be considered.[10] Turning, then, to the most modern type of ship, like the "Louisiana" or "Pennsylvania" or "Connecticut," we find a relatively commodious, admirably equipped emergency hospital, consisting of wards, isolation room, dispensary, bath-room, closet, and operating room, modern in all its appointments. All the indispensable requisites are provided and placed in a manner that is irreproachable for operation, dressing, and all medical care. In addition to modern aseptic furniture, instruments of precision, laboratory facilities, an elaborate surgical outfit and sterilizers, not to mention an abundant store of dressings and other material, there is good

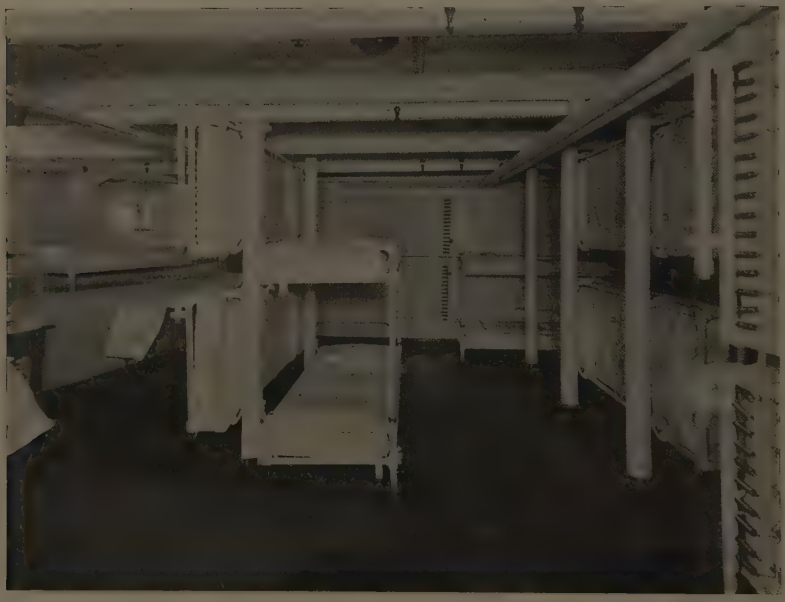

FIG. 508.—SICK-BAY, U. S. S. "CONNECTICUT," SHOWING TYPE AND ARRANGEMENT OF COTS.

light and ventilation, hot and cold water, ice, etc., and, above all, attendance by trained nurses qualified to undertake all the duties of their calling.

The accompanying illustrations and plans clearly depict the completeness of the navy's provision for sick and injured at sea.

Technic.—When operative procedures are necessary on board ship, there is but one thing to be said: that the surgeon should always give preference to those which are simple and of easy application within the needs of the particular case. He should reject any procedure which savors of innovation and which has not fully established its safety and utility among standard operations.

In time past there were very essential and important points of difference between applied surgery ashore and afloat as expressed in the then

unattainable surgical cleanliness, which relies more upon asepsis than antisepsis. Then, too, poor illumination and bad ventilation and inadequate assistance and nursing were unfavorable to the efficient conduct of an operation and the after fair progress of the case. But today, with the exceptions found in the remnant of the old navy, operations of whatever gravity cannot be deferred legitimately on the ground of insufficient material equipment or conditions unfavorable[11] to the immediate purposes of the operation and the after-care of the patient during convalescence. Indeed, every convenient fitting for a strict compliance with advanced surgical technic is provided, and "the principles which at all times and under the most trying conditions should guide the surgeon

FIG. 509.—DISPENSARY, U. S. S. "CONNECTICUT."

here in his work must be the same that are recognized as good surgery by the profession at large and practised in all civilized hospitals the world over." [5]

As has been said, academically speaking, there is no reason under ordinary conditions on board ship why any operation should not be performed with equally gratifying and happy results to both surgeon and patient, but we nevertheless hold that, owing to possible attending circumstances, such as rolling at sea, coaling ship, saluting, etc., no unnecessary or deferable operation of a major character should be undertaken, if with entire justice to the patient he can be sent to a hospital. In this connection it may be further said that each case of serious illness or endangered life needlessly retained on board, through its mere presence

cripples by just so much the efficiency of the ship and has a very real and evident depressing influence over the entire personnel. While it is impossible to make any hard and fast rule as to what shall or shall not be operated upon on board ship, it may be said in general that cases of surgical election should be sent ashore; but the discrimination between the merely desirable and the imperative must be more or less arbitrary. Just here theory often fails in practice. There is no definite line of demarcation. Circumstances will ever alter the case, and in the end decision will still rest upon the careful judgment of the individual surgeon.

Anesthesia.—The question of anesthesia is much discussed in naval medical circles, but it seems no more fraught with danger here than

FIG. 510.—OPERATING-ROOM, U. S. S. "CONNECTICUT," SHOWING COMPLETE EQUIPMENT.

elsewhere. If any warning is needed in regard to the administration of general anesthetics on board ship, it is that every precaution must be rigorously observed, overdosage carefully avoided, and every possible untoward development anticipated; but, after all, this should be superfluous advice to any efficient anesthetizer. It is well to make provision against the emergency need for an abundant supply of fresh air, by an electric fan or a portable canvas conduit leading from a nearby ventilating louver. This perhaps expresses the only unusual provision for such an accident as overdosing.

It would seem that spinal anesthesia, where applicable, or local anesthesia should have a particular field of usefulness in naval surgery, more especially during or after engagements. It is unnecessary to enu-

merate their many theoretic advantages in comparison with general anesthetics. It will be enough to present the few which apply to the circumstances of naval practice under consideration. These appear to be:[12]

First, the immense saving of time and attention in administration; second, the saving in operating personnel (dispensing with the necessity of an anesthetizer); third, the saving in number of attendants for individual patients (after operation the patient does not require such

FIG. 511.—BATH-ROOM, U. S. S. "CONNECTICUT."

attention as after general anesthesia); fourth, saving in number of bearers (the patient being frequently able to assist himself); fifth, their employment would relieve suffering and at the same time eliminate the inherent dangers of general anesthetics and go far toward preventing nervous shock.

ORGANIZATION OF THE MEDICAL DEPARTMENT AND PREPARATION FOR BATTLE.

The progress noted in construction and ordnance must be followed by equal development in the medical department. In the navies of today

everybody attends with keenness and avidity to the advances in technic along their special lines. The doctors play their part by their attention to the progress in medical science as applied to naval warfare, and by adjusting their organization to conform to the changes in construction, armament, and service conditions generally, as expressed in the probable effect which modern maneuvers and gun fire may have in inflicting injury. More and more conditions demand careful and detailed anticipatory consideration for the succor of the wounded, and we cannot treat as a negligible quantity the humane part of the naval program; viz., the organization of the hospital service in preparation for battle.

A naval battle is a very formidable affair—much more so than a land fight, and very different from it; for in modern times it is entirely dependent on the fire and destructive effect of heavy ordnance, on ramming, or on the discharge of fish-torpedoes, by which a whole ship may suddenly be destroyed or sunk, even when it is simply penetrated by shells without exploding. Small arms play no decisive part.[5] Everything that is movable is thrown overboard; but there remain ship's planks and stationary furniture, etc., which may be destroyed, and many lives are lost or injuries sustained from flying splinters.[13a] When the shells explode, fearful damage results, as they are immediately transformed into a multitude of missiles of greater or less size and weight, and, as a rule, form zones of such destructive energy that only armor of some inches can withstand them.[5] Special armor-piercing shells are even more destructive, and the contest for supremacy between these and the armor which covers the flanks of ships still rages.

The Surgeon.—The duties of the naval surgeon in the intervals of peace must hereafter include a more active and serious preparation for the worst that can be inflicted in time of war and place himself and his department in entire readiness to assume that professional responsibility which the Government has confided to him. The problems presented as to the care of the wounded in action were never so imperative and grave.[4] *Semper paratus* is the keynote to the efficient and expeditious conduct of the medical service in those supreme moments for which the navy exists, and this forms an important part of the surgeon's responsibilities from the hour he joins his ship.

Preparation for battle does not consist solely in the general arrangements for the wounded on board ship. Naval surgeons begin to prepare for battle in the Naval Medical School, for unless they be professionally competent and well instructed in the peculiar features and requirements of their chosen field of practice they will be of little avail to the wounded during a naval engagement. At such times there is no substitute for coolness and sound general and specialized professional knowledge.[9] In this connection it is to be remembered that every consideration, however slight, which makes for naval prosperity and success, is of importance, and few, perhaps, more than that which tends to give confidence to the combatants in the assistance which awaits them should they be wounded in battle. Seamen, though in other respects so inattentive to their own

welfare, in no small degree appreciate the merit of their surgeon on such an occasion.[15]

First-aid Instruction.—In further pursuit of this realized need to fortify the morale, modern first aid, that great boon to suffering humanity, is given a large place in the routine drills, and it serves the additional and equally important necessity of offering a measure, through the aseptic protection of wounds, for the curtailment of disability and the conservation of life. Not only are the members of the hospital corps thoroughly and unceasingly drilled toward perfection in emergency relief, but the officers and crew of every ship are given such instruction in first aid—the kinds of packages, their contents, and the method of application; the use of the tourniquet; and the various modes of transportation, as will give them a certain sense of independence and helpfulness in the presence of wounds.

Statistical Considerations.—In the intelligent preparation for battle as regards arrangements and surgical supplies, the probable number of wounded is to be taken into account, as thus only can ample provision be made. This element of consideration must, of course, always remain more or less problematic, as there can be no method of exact calculation to determine it. A vessel may bear the brunt of heavy gun fire for a few moments and receive appalling punishment while others in the same fleet may suffer but little; hence, casualties vary most unexpectedly in the same general engagement.[5] Since the Russo-Japanese war more definite conclusions in this direction are possible, as accurate data concerning naval casualties are becoming available. Statistics show casualties ranging from one-fifth to one-third of the ship's company in the old service, though it is fair to assume that the latter is more nearly correct. In future naval conflicts—ships being evenly matched, for instance—the personnel will not be considered as having suffered excessively if one-third are killed and wounded.[5] Be that as it may, prudence exacts that the surgical service be established on such a basis, and it would be criminal neglect to provide for less. It is not likely that this number will be greatly exceeded except in such disasters as the "Hatsuse" or "Rurik" and others suffered in the Russo-Japanese war, in which case the medical service is effaced as it was in the old days of maritime warfare, when boarding and hand-to-hand fights were common.

The rate per cent. of killed and wounded for each class, under the heads of officers, seamen, combatants, and non-combatants, shows that surgeons and medical attendants have the largest rate; next officers and seamen, engineers and stokers having the smallest rate. In naval battles hostile shells do not choose any one place for striking a ship above water-line; those standing on the bridge or those manning an open battery or those working on a lower deck run equal risk of being struck; so there is no reason for supposing that there would be any difference in the number of injuries between combatants and non-combatants as long as they are equally engaged in their duties above the water-line. On the other hand, below the water-line one is almost always safe from a hostile shell, though this is not absolute, for whole shells and fragments may drop into

the bottom of a ship.[16-42a] Of course, the men so located are subject to the far-reaching effects of interior explosions, and are in the greatest danger from the destructive effects of mines and torpedoes and indirect missiles, such as broken pieces of structure and splinters.[13a]

Posts for the Wounded.—The selection of dressing stations or surgeries or posts for the wounded, as they are variously called, and the accessory or relief stations, presents a serious responsibility. Needless to say, the regular sick quarters, owing to their usual situation and the fact that they are rarely if ever protected by heavy armor, become untenantable in engagements and must be abandoned. Indeed, it would be difficult to find an available space for the establishment of a dressing station above the water-line that is not vulnerable, for nothing but the heaviest armor will protect against the largest guns, and these large guns are displacing the smaller calibers and are being placed in pairs and protected at the expense of the rest of the ship—all but the vital parts. The tendency in naval construction has created an apparently irreconcilable conflict between the desirable features of such stations and the undeniable demand for protection, and a compromise must be accepted by practical students of this question. It is important, however, that the ideal requirements be understood, so that the relative value of each may be intelligently weighed in seeking to adjust the principles concerned to the complicating changed conditions.

It is held that the dressing stations should be: convenient for the collection of the wounded from different parts of the ship; accessible for those who are able to assist themselves; so placed that they will be least liable to be disturbed by hostile shells and with further reference to commodiousness of deck area, air space, and light.[13a] It is manifest, from an investigation of present-day ship construction and with the knowledge that all compartment communications necessary to offensive operations are closed as a defensive safeguard, that the several needs cannot be combined in a single station, as in the days of the old wooden ship, when hatches and companionways and passageways were roomy and the decks were not cut up or encroached upon, and as was lately attempted by striking an average (more or less) between the conflicting requirements and doing the best possible on such a basis to establish efficient dressing stations. The result of this experiment was disastrous in point of enduring efficiency. Instances in recent wars prove the fallacy of the contention which sacrifices a vital portion of each element and is satisfied with a composite but defective whole, and it is now recognized as absolutely ridiculous to establish a dressing station which will have to be deserted. The medical service, therefore, must divide its forces and establish a number of stations under increasing degrees of protection—a chain of relays, as it were, from points near the scenes of fighting activity to locations farthest removed from the danger of disturbance or destruction. Each such type of station aims to meet at least one of the requirements, but, taken together as a system, the ideal whole is complete and the closest approach to the best possibilities of the medical service may be realized.

Primary Stations.—First, one first-class or primary station must be

located either behind the heavy armored belt or below the water-line, preferably the latter, though in lieu of opportunities to comply with this regulation, it is to be remembered that masses of coal have been found to offer relative protection[16] and a space between the bunkers could be selected. Due regard must be given to the transportation routes, but where this consideration does not encounter insuperable obstacles, the insistent demand for a protected locality must influence the choice of this station. It is possible that such a primary station, with artificial ventilation and electric lights, may be made to combine all of the desirable features except accessibility; but, as its particular purpose is to insure safety; to provide facilities for the care of the few gravely wounded who may require operation as a life-saving procedure; and to guarantee, as far as the fortunes of naval battles permit, a well-equipped place where more serious work may be carried on during and immediately after the battle without interruption in case the regular sick quarters have been demolished, or until they can be rehabilitated, this defect is sufficiently compensated by the functions of the secondary and relief stations. The future may bring such an accommodation as this primary station requires. With the growing size of ships, architects may give some heed to this demand and construct a compartment in some protected place, with specially arranged means of communication, for this specific purpose. This need not interfere with the general efficiency of the ship, but could be adapted for other purposes, such as a store-room, and turned over to the surgeon only in the event of war.

Secondary Stations.—Second, two secondary stations must be located—one forward and one aft—in, at least, a partially protected place. Of course, the more protection the better, but in choosing these stations equal weight must be given to the question of accessibility, their purpose being the care and protection of those seriously wounded, who, for one reason or another, cannot be transported to the principal station until there is a pause in the battle or it has come to an end.

Relief Stations.—Third, a system of relief stations must be established, connected with and as outposts of each secondary station, for the purpose of gathering in the wounded at opportune moments, rendering first aid, and passing them on to more competent hands; and at the same time capable of acting independently in administering simple attention. These stations must be located with some thought of protection, if possible, but nothing of their chief purpose should be sacrificed to that consideration. Their function demands that they be placed near exposed gun crews and in parts of the ship where accidents are likely to occur and where men are serving. There can be no stipulation as to their number. As many as possible within reason are desirable, and it may be necessary to establish one for each separate compartment. In selecting the most useful locations, the surgeon must take into account the limited number of assistants at his disposal and bear in mind that commanding officers will carefully safeguard their men, by ordering those not actually engaged to keep below during long-distance fighting, and that the smaller unprotected guns would only be manned to repulse a torpedo-boat attack.

This system of battle stations for the surgeon's division is formulated with particular regard to the newer ships and the present tendency in construction. It, however, represents a principle, and the old ships of the navy or the smaller ones built for special service must adopt the system as far as possible.

Disposition, Arrangements, Supplies, Etc.—In war, where all is uncertain and sudden, nothing that can possibly be foreseen as necessary in the surgeon's arrangements is to be left to chance. The importance to the men who fall in battle of proper organization, faultless preparation of instruments and dressings, etc., and well-chosen posts makes it a subject for the utmost solicitude. Though the army can and does have one definite scheme or organization for the care of the wounded, applicable throughout the entire service, and generally under all circumstances, this seems more or less impossible in the navy, owing to the variation in types of ships and the more limited number of assistants available, etc.[17] In the question of organization, therefore, each ship or type is a law unto itself and must be specially considered. Fortunately the Government is now building in larger classes, so that we can more nearly approach the comparative simplicity of task imposed upon the army medical corps, in that a scheme carefully worked out for the "Vermont," for instance, is with minor changes applicable to four sister ships. There are, however, certain well-defined and universally conceded principles in the disposition of the naval medical department which must and do guide us in the preparation for battle on all ships, formulated after a conscientious study of experiences in the last twelve years, beginning with the Chinese-Japanese war (1895). There is diversity of opinion in this, as in most matters of import, which at first thought seems to complicate the problem and to embarrass the solution, but in the United States we have come to regard the matter as settled for the present, at least, and instructions, embracing the established principles, have been issued "for the guidance of the medical corps"[18] and for the information of the service. The adaptation and elaboration of this working plan usually devolves upon the senior surgeon of each ship, with the approval and assistance of the commanding officer, and he must exercise the resources of his own judgment for such arrangements before, during, and after battle, as he may think will abridge his labors and conduce to the perfection of the aid he is expected promptly to render to the wounded.[19]

When action is expected and all hands are summoned to their respective quarters, there are certain well-determined dispositions and final arrangements which fall in the domain of the surgeon and demand his immediate attention. Experience has taught much, both as regards admissible and inadmissible provisions, but still to a certain extent laying out a definite plan in trying to regulate the impracticable,[17] for well-nigh insuperable obstacles are inherent conditions of naval vessels and the succession of events is rapid and terrible and often overwhelming. Such are the desiderata which the surgeon must bear in mind and in the presence of which he must prepare his department and fortify his mind against the inevitable events of an engagement in order that he may act with calm-

ness, energy, and efficiency. It is necessary to make minute specific provision with a clearness of discernment and expedition assured by repeated drills, and to satisfy himself that the disposition made will respond to the necessities of the trying conditions of the coming emergency.[10]

Reviewing the points for consideration at this important time we find:

The Sick and Disabled.—These must be moved to a place of safety behind the armored belt or below the water-line where their presence will not interfere with the operations of the combating force. Those who are convalescent but not well enough to go to regular posts or whose malady is not an impediment, together with assigned non-combatants, may be employed in rendering useful services to the surgeon.[10]

Medical and Surgical Supplies.—(*a*) *In General.*—Indispensable supplies should be divided among the dressing stations to avoid the danger of destruction of the entire equipment and of being thus reduced to a condition of utter helplessness. This policy serves the additional purpose of economizing time for those engaged in the succor of the wounded in various widely separated parts of the ship. Hospital material is to be moved to the designated places by the hospital corps, who understand their value and use, because it is vastly important that all articles necessary to a completely equipped station be properly distributed.

(*b*) *Detailed Outfit.*—The dressing stations must be outfitted in conformity with the degree of relief to be undertaken during battle; and also, with a foresight of the probable number of wounded and the nature of their wounds, and all arrangements must be in keeping with the serious character of general action. Each dressing station must be entirely independent in this respect, as far as available special instruments will permit. The equipment of the primary dressing station must be the most complete and all valuable supplies in excess of the needs of the other stations should be stored and safeguarded there. There is, of course, no difficulty experienced in dividing the common supplies, such as dressings and other surgical accessories, and such medicines as would be used in emergency work. The usual outfit should consist of: (*a*) Anesthetics—chloroform and local anesthetics; (*b*) hypodermic provisions—including syringes, sterile water, and drugs—whisky, aromatic spirits of ammonia, digitalin, ergotin, strychinin, atropin, morphin, and adrenalin; (*c*) disinfectants and appliances for cleansing—tincture of green soap, nail-brushes, razors, basins, trays, two liters of carbolic solution (5 per cent.), five gallons of bichlorid of mercury (1 : 1000), at least five gallons and as much more as obtainable of boiled water, a large quantity of normal salt solution, Davidson rectal syringe, irrigator and transfusion needles, and a large quantity of ½ per cent. picric acid solution; (*d*) dressings, sutures, etc.—cotton, plain gauze, iodoform gauze, picric acid gauze, lint, towels, sheets, operating gowns, gauze and muslin bandages, rubber drainage-tubes, tourniquets, safety-pins, assorted sizes of silkworm-gut, silk, plain and chromicized catgut, and assorted needles; (*e*) instruments: all instruments are to be laid out for quick selection and the most commonly used are to be ready sterilized; (*f*) accessories: pus basins, buckets, pitchers, Kelly pads, etc.

All articles above enumerated which are to be sterilized must be ready

prepared as required. Those dressings not ready for use as supplied are to be cut and packed in towels and sterilized by steam. The operating table and all movable and necessary operating-room furniture are to be transported to the principal battle quarters. For the secondary dressing stations other operating tables must be improvised by the ship's carpenter, though generally the small mess tables will suffice for the purpose. In respect to other required furniture at these stations, similar provision will have to be made. No glass containers should be used here except such, perhaps, as are surrounded by wickerwork. Among other things in clearing the ship for action, inflammables must be boxed or otherwise made ready to throw overboard upon the order. Lanterns must be put in order and matches provided, in case the electric circuit fails, also swabs for mopping up decks and a sufficient quantity of drinking-water.

The relief stations must be outfitted with mattresses, first-aid dressings, tourniquets, stretchers, and life preservers. They should also be fortified with hammock rolls and the bulkheads may be covered with tarpaulin to catch fragments and splinters. These precautions should also be employed at the secondary dressing stations.

Personnel—Surgeon's Division.—This will include medical officers, hospital stewards, hospital apprentices (nurses), and others of the crew assigned to assist in the hospital work.

(*a*) *Senior Surgeon.*—If there are two or more surgeons, the senior will take his position at the principal dressing station ready to receive the serious and urgent ones. If but one, this dressing station will still be his post, and from there, as need be, orders and additional supplies may be issued to his staff serving at such other stations as the type and size of the ship make desirable. It is well for the senior surgeon to keep in touch with the captain, if possible, as he alone can determine the propitious moment when the considerations of humanity may be permitted to supplant consideration of the naval operations which always take precedence in point of importance.[20] In this connection it must be remembered that the business of every one on such occasions as we are now anticipating is to secure the greatest efficiency of his own department without trenching on that of others,[19] and thus contribute, not only actively but passively, to the achievement of the hour.

(*b*) The *junior surgeons* will occupy the secondary dressing stations. If there is only one junior, he will alternate between these stations, work being prepared at one while the other is in use. If unengaged, he will also make periodic excursions to the relay of relief stations. In the absence of a junior surgeon this duty will be assumed by the hospital steward.

(*c*) The *hospital steward* will be attached, with the senior surgeon, to the principal dressing station, and act with this post as a center, bearing orders to the various accessory stations and giving any needed relief to those wounded who come under his observation. During the interval he will assist at his regular station, administering anesthetics, hypodermic injections, applying dressings, and in other ways making himself generally useful. In the absence of a junior surgeon he will assume his duties as far as his knowledge will permit.

(*d*) The *hospital apprentices*, or nurses, will be detailed according to their number—at least one (preferably two) at each of the dressing stations, to sterilize instruments, to prepare solutions and dressings, and apply the latter, or to assist in any operation. If there are a sufficient number, it is desirable to have a nurse at as many of the relief stations as there are nurses available, but particularly, as far as can be foretold, at the one most likely to handle the greatest number of the wounded.

(*e*) The *non-combatants* assigned to the surgeon's division are to be carefully trained in giving first aid to the wounded and, when the ship is being cleared for action, the men so assigned report to the medical officer, who details them to ambulance and special emergency duties at the relief stations, giving them final instructions in regard to their duties. These relief station crews should consist of four men each and have no other duties to perform; but in case the complement does not permit of this, they should be drawn from the stations from which they can be spared for temporary service. In no case, however, where it is possible to avoid it, should they be members of main or intermediate battery gun crews, either on engaged or unengaged sides. They will usually consist of such members of the crew as musicians, mess attendants, cooks, etc.

Finally in respect to the personnel of the medical department, the surgeon ascertains that the members of his staff know their stations and clearly understand what part they have to play, so that there may be no hampering confusion in time of action.

First-aid Dressings.—(*a*) *The Packets.*—Everybody is familiar with the character of the small first-aid packet as used in the army, but in naval warfare, as over 90 per cent. of the wounds are of large size,[51a] their adequate protection demands a dressing of more ample dimensions. "Stokes' shell wound packet" was planned to satisfy the first-aid indications of such wounds. They are made as follows:

"A piece of No. 16 galvanized wire gauze is shaped into a parallelogram 8 inches by 6; 4 feet of gauze is cut off the roll, is folded lengthwise, and is securely stitched to one 8-inch side of the wire form. The wire frame is filled with cotton in the form of a compress and the gauze is folded over it and is stitched to the frame for security. The remainder of the fold of gauze still attached is snugly wound about the rigid compress. A piece of unbleached muslin 4 feet long and 9 inches wide is then stitched to the free end of the gauze and it, too, is made to encircle the form. Its free end is nicked with the scissors at several points so that the whole dressing may be easily secured by splitting and tying the muslin. Three safety-pins fix the muslin at the sides and ends." This dressing can be made on board ship, sterilized there, and is to be prepared in quantities only when likely to be needed in actual warfare.

(*b*) *Distribution.*—First-aid dressings are very important for emergency use, should a relief station crew fail for any reason to visit the division suffering injury, and where, as in modern battleships, the injured are often isolated and dependent upon their own or a shipmate's ability to relieve. Every man is to be provided with an individual packet to be attached to his person at some uniform place, and, in addition, canvas

bags containing an abundant supply of these packets, particularly for shell-wounds,[14] are hung on a stanchion or bulkhead behind each exposed gun and in the casemates. The turret will be equipped amply with first-aid provisions and the turret crew will attend to their own wounded, laying them aside where they will not hamper the operation of the big guns. It may be possible for members of the surgeon's division to reach this part of the ship and succor the wounded during action; but against the fact that such visits might prove impracticable, the turret crews must be given

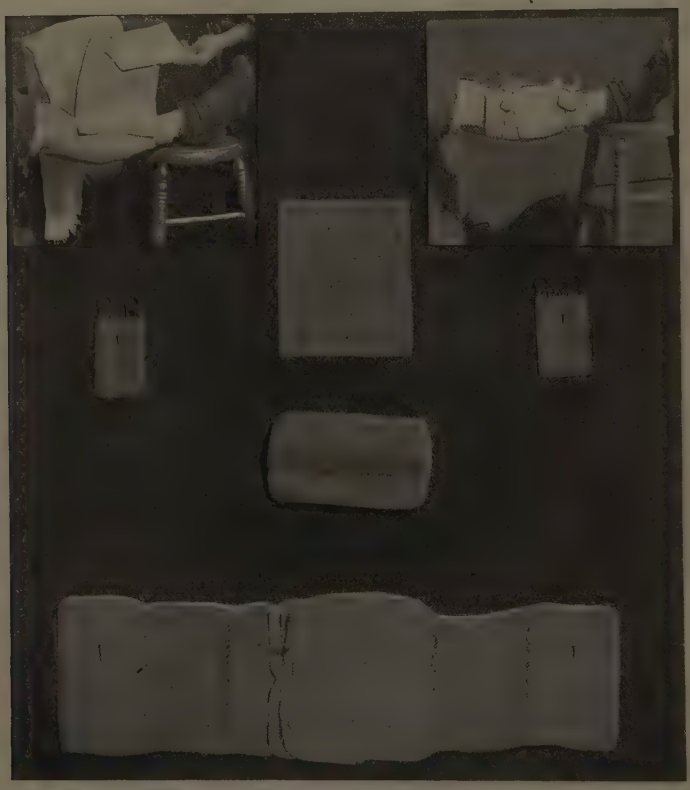

FIG. 512.—THE UPPER PORTION OF THE ILLUSTRATION SHOWS THE SHELL-WOUND DRESSING BEING APPLIED, ALSO SAME COMPLETED. THE LOWER PORTION OF THE ILLUSTRATION SHOWS THE CONTENTS OF A FIRST-AID PACKAGE.

special training in first-aid methods. Indeed, the practical and careful education of the whole body of officers and enlisted men is essential to future progress in the treatment of wounds.[13b]

Clothing.—In entering upon an engagement, time permitting, the whole ship's company, particularly those above the water-line and in exposed parts of the ship, should bathe and shift into clean underwear and overgarments (as few as needed), with a view to minimizing the chance of that serious infection which has in the past been a prominent

characteristic of all shell-wounds, owing largely to the sweat of unclean skin and to soiled clothing which is carried to greater or less depth in the wound by the injuring missile. This precaution might well be carried a step further, and a set of underwear for each man, done up in a little bundle, labeled and sterilized and stowed away ready for issue at the required time. Thus the desired aseptic undergarments for each man would be assured and could be expeditiously distributed by divisions and name. This idea comes from the Japanese, who suggest, also, that each gun's crew be provided with a bucket of boric acid solution for laving their eyes when temporarily blinded by smoke and powder-dust. Pneumatic or rubber-soled shoes for those serving in the vicinity of guns are recommended with a view to diminishing the upward vibration and lessening the violence of shocks.

Protection of the Ears.—The imminent danger of that serious yet in a measure preventable accident, rupture of the tympanic membrane, demands prophylactic consideration in preparation for battle, and every man should be compelled to place a pledget of cotton or its equivalent in each ear. The necessity of compulsion in a matter so rational may be a surprise to some, but the advice is no mere waste of words. "Neither officers nor men take kindly to the use of artificial means,—cotton, wool, etc.,—although the practice is more universal than it was a few years ago. The discomfort caused by the presence of a foreign body in the ear, added to the dullness of hearing produced (a serious condition where orders of command are of vital importance), are the chief reasons for this, and the sailor considers it too effeminate."[29] The cotton should be loosely packed so that it will not touch the tympanum, and as an additional precaution, the mouth may be kept slightly open for the purpose of equalizing the pressure on the drum. These expedients somewhat lessen the likelihood of rupture and traumatic myringitis caused by the impact of suddenly compressed air or repeated violent air vibrations, but the open mouth access to the Eustachian passage "must tend to intensify air concussions on the foramen ovale, and therefore increase the agitation of the fluid in the labyrinth."[29] Elliott has advanced a pace in prophylaxis along this line and has shown ingenuity by the invention of a little device which is an excellent substitute for cotton, and in several respects is superior to it. It consists of a small, tortuously perforated celluloid ball and wing, the former fitting snugly into the auditory orifice and being firmly held in place by the latter, which presses back against the auricle. Its particular merit lies in the fact that while the voice is distinctly heard, the shock to the ear is reduced below the danger-point. Cheatle, of England, believes that he has found the material which will accomplish the dual purpose of preventing deafness and enabling a man to hear orders given. It is a mixture of animal wool and modeling clay, is easily worked into the ear and easily removed, and being plastic, fits the aural passages of ears of different shapes and sizes.

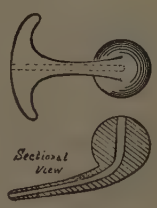

FIG. 513.—ELLIOTT EAR DEVICE.

Conclusions.—The last duty of the medical officer in the time between the call to quarters and the time the action actually begins is to make a final inspection of his dispositions and arrangements, to assure himself that every provision is in place and nothing forgotten. A buoyant, encouraging demeanor, no matter what his fears may be, and an occasional well-directed cheering word, are also, in a moral sense, a part of his duty in this preliminary stage and during active hostilities as well.

CONDUCT OF MEDICAL DEPARTMENT DURING BATTLE.

During battle the efficiency or inadequacy of these arrangements will develop, but it must be remembered, in judging the results in any particular case, that the brevity of engagements between large ships and the rapid succession of events in modern naval warfare, coupled with the complex construction of ships, will severely try any hospital organization, no matter how perfectly conceived, practicable, and thoroughly drilled it may be.

"It is a naval maxim that the greatest possible weight and rapidity of fire in the minimum of time win battles, and, when once the enemy has the correct range, the amount of shot and shell that it can throw into an opposing ship is so appallingly great that there will be no time for thinking out new problems."[5]

Personnel.—The conduct of the surgeon and his staff under these conditions must conform with the principles which experience has dictated as wise and most calculated in the end to subserve the best interests of humanity and the business in hand.

The life of at least one of the surgeons must be absolutely safeguarded against the time when his services will be most urgently needed, and the other officers and the hospital corps must avoid exposing themselves unnecessarily. This dictum expresses a consideration—not of person but of principle, as the hospital staff cannot be replaced on board ship and its most important duties are performed when the action is over. Excessive zeal is not in conformity with this rule, and is entirely out of place in the conduct of the medical personnel. They must be indefatigable and active, but exercise the courage of prudence instead of recklessness. It must be said that this required position is not a comfortable one, as there is nothing so disturbing or threatening to the morale as an unseen danger, but the after-battle needs are for a whole surgeon, ready to perform his full legitimate duties, and not a wounded, disabled hero. Most of the surgeon's work of relief will come at this time.

Scope of Relief.—During the bustle and excitement of action, unfortunately, circumstances force the surgeon to sacrifice his professional conscience and do comparatively little; while to his shipmates he may seem to be neglecting his plain duty, though in reality he is acting according to approved judgment. His principal object should be to stop hemorrhages, to quickly dress wounds not seeming to require more extensive immediate attention, and to perform operations of an urgent nature only. If possible, therefore, he should content himself with endeavors to save

life until he is less hurried and harassed by the scene of suffering and bloodshed as the wounded are crowded upon him, and by the smoke and din and uproar which surround him. He may, however, find opportunity to administer appropriate medicinal agents, to wash wounds and disinfect the surrounding skin, hurriedly to set fractures and apply temporary splints, to assort the wounded and prepare them for transportation, and, in general, take pains for their comfort and protection from further injury. If foreign bodies or extraneous matter are seen without the necessity of exploring the wound, they should be quickly removed before dressing; but if they are not plainly in sight or there would be any difficulty in their removal it will generally be better to defer their removal until a calmer interval. Attention to slight injuries, such as involve no danger, may be deferred in favor of those cases which are serious; on the other hand, the unwisdom of engaging in a serious or lengthy operation at this time is apparent. It should not be dreamed of, and any transgression of this rule would be the greatest imprudence and injustice. Furthermore, even if all other circumstances were favorable, prolonged chloroform anesthesia would be hazardous, and ether is condemned as an inflammable.

Above all, the surgeons should place the gravely wounded in a location where they can keep their eyes on them and exercise an active surveillance against any sudden and alarming change in their condition. Each case cared for should be immediately tagged to save duplication of dosing and unnecessary handling of wounds, and careful though brief notes should be made at the time to insure accuracy of the official report.

While the foregoing may be said to limit the surgeon's admissible cares and intervention during battle, it is probable that intermissions will occur and give opportunity for further and more important work on the cases he had put aside as of secondary concern or too complicated to undertake at once.

Hemorrhage is undoubtedly the most alarming and urgent symptom presented to the surgeon during battle.[9] A general or superficial oozing of blood from a wounded surface may not be immediately pressing in the face of other more urgent injuries, but bleeding from a wounded artery will at once demand aid, and where the bleeding is profuse, everything must be set aside until the vessel is secured.

Immediate amputation may be necessary when a limb is shattered so high that a tourniquet cannot well be retained; but in facing a surgical question of this nature, the dictates of conservatism must be given due regard and should guide in the decision as to proper action. Penetrating wounds of the abdomen and thorax should be regarded as urgent, though it may be impossible to do more than temporize in these cases,[21] so complicated is their thorough management. Fracture of the cranium with pressure symptoms will require immediate attention, to the extent admissible within the circumstances. In this the elevator will be found of greatest value, as the more delicate manipulation of the trephine may have to be deferred until after action. In case of fatal injury, something may be done to palliate the condition of the dying man by means of position, opiates, or stimulants.

Disposition of the Wounded.—That the medical staff can gather in many of the wounded during battle, and often have done so, are facts which do not enter into this didactic consideration. There is, and can be, no regulation in the premises. The surgeon must be relied upon to exercise quick and good judgment in those unforseeable events against which no provision can be made, and which make each battle a law unto itself. The time of battle, type of ship, and attending circumstances must ultimately guide in reaching any decision as to the conduct of the medical personnel.

A junior surgeon or a hospital steward making periodic trips to the various relief stations will inspect the wounded personally and ascertain that they are receiving needed attention, giving additional relief himself whenever it seems desirable. At these visits also he will examine the wounded critically and return them to duty or send them to one of the dressing stations for further attention according to the extent of the injuries. Those not able to return to their posts, but who are doing satisfactorily under first-aid dressings, will be made as comfortable as possible out of the way at the relief stations. It is often possible to determine at a glance whether the wounds are likely to become the subject of early operation or admit of delay and a more deliberate examination; this facilitates the disposal of the wounded and secures attention where needed and at the proper time without any misdirection of energy or lost opportunity. Besides, the welcome assurance that can be given to a sufferer that his wounds are not of a serious character or attended with danger tranquillizes his mind and becomes a veritable nerve stimulant. A well-stocked medical department haversack (large size) will be the portable equipment for these visits, which must be accomplished with the greatest expedition consistent with due thoroughness. This system of rounds is also the means of reproviding the relief stations from the primary or secondary post.

Fig. 514.—Naval Hospital Corps Pouch, Large and Small.

The ambulance parties or relief station crews are constantly to visit the various accessible parts of the ship in their vicinity where wounded men are likely to be found, as at the guns, and when possible, remove them to the relief stations. In these searches they will always carry a haversack of first-aid dressings, and they will, if possible, administer first aid before attempting the traject. The wounded who are able to

walk will proceed to the nearest relief or dressing station, and others, according to the phase of the combat, will be transported to the most available shelter, there to remain until a lull in or the end of the fight. This traject will be performed by fellow-combatants or the relief station crews; and it is to be remembered, in regard to this disposal of the wounded, that the unengaged side is more dangerous than the firing side—that is, the one exposed to the enemy—as the fragments of bursting shells are dispersed in a radiating manner.[22] Moreover, as an additional precaution against further injury, any considerable grouping of the wounded must

FIG. 515.—CONTENTS HOSPITAL CORPS POUCH, LARGE.

not be practised, even though space allows, except where protection is afforded by heavy armor.[5] In isolated compartments it is probable that the gun crews will have to apply first-aid dressings and lay their wounded aside as the only possible disposition, and with that limited resource in view, each such compartment may be provided with a few mattresses, if they will not occupy space needed for battle purposes.

It would seem a matter of ordinary humanity that the wounded should be removed to a place of safety from further injury; yet, at the risk of contradiction, one cannot afford to lose sight of the character of naval

battles in modern times and the obstructing wreckage on the decks which may result from the storm of projectiles, bringing those engaged in relief work face to face with the necessity of leaving the wounded men where they fall and attending them there by first-aid methods. Even such meager attention is sometimes impossible. This applies particularly to the defeated ship.[5] Experience in the Chinese-Japanese, Spanish-American, and Russo-Japanese wars may be taken as conclusively demonstrating the probability of periods of such enforced inactivity on the part of the surgeon's division. Indeed, this is frequently stated as a principle,

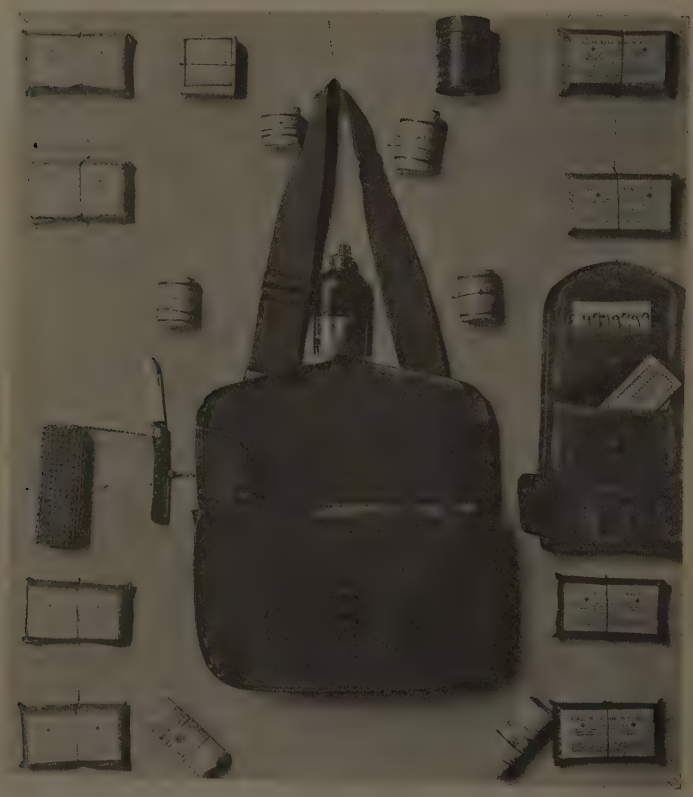

FIG. 516.—CONTENTS HOSPITAL CORPS POUCH, SMALL.

but it is deemed inadvisable to make a hard and fast regulation of this sort, as it would be most detrimental to the moral fighting trim of the men on the one hand, and on the other, would interfere with that desirable free-play of discretion which must be confided to the surgeon.

In further reference to the disposal of the wounded, however, it can be stated as a principle that they should not be allowed to lie around, with due considerations for all the requirements of the hour, if this undesirable state can be avoided. They should be cleared away for three reasons: First, humane; second, military, so that they shall not encum-

ber the vicinity of the guns or other space being employed for offensive purposes, and actually hamper the work of the combatants; third, moral, so that depressing influences which they might exert by their presence may be prevented. These three considerations apply with increasing force to: the seriously wounded, the hopelessly wounded, and the dead. The dead are to be thrown overboard, as during a sharp action they are but an incumbrance, and the sooner they are disposed of the better. This is one of the grim actualities of war.[16] Of course, the danger of leaving the wounded behind, as in land operations, does not have to be considered, all sharing in common the fame and fortune of the ship.[5] But there are enough problems without that to embarrass the surgeon. Fortunately there occur in all naval conflicts pauses due to

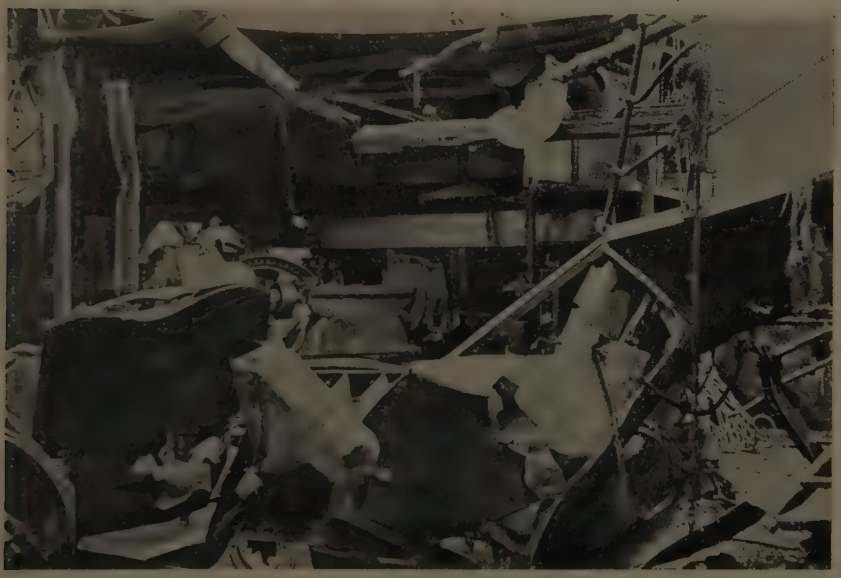

FIG. 517.—WRECKAGE ON UPPER DECK OF "OREL," FROM STORM OF EXPLOSIVE MISSILES (BATTLE OF JAPAN SEA, MAY 30, 1904). SHOWING DIFFICULTY OF GIVING FIRST AID TO WOUNDED.

tactical maneuvers, and during these cessations of fire, which should be eagerly watched for, the surgeon may hope to remove and relieve the wounded to some extent, the surgeons and members of the hospital corps and stretcher-bearers busying themselves clearing the gun positions of disabled men and carrying them below to the dressing stations or to positions of safety. Regardless of these lulls, however, there may be calls for assistance, whenever the wounded fall in great numbers in any locality, and the surgeon's division, particularly those at the relief stations, must be on the alert to catch the signals and cries for help above the deafening roar of the guns. At these times the relief station crews must hurry to the indicated locality and work with great alacrity in their search for and the succor of the wounded.[13a]

Transportation.—The question of transportation methods during

the turmoil and confusion of battle has not yet been satisfactorily solved, except so far as it conforms to the consensus of opinion that no one form of stretcher, however ingeniously made, is suitable on board ship at this trying time. Broadly speaking, the modes of carrying the wounded must be various, as the size of the ship varies and as the hatches, ladders, and passages and general construction favor one or the other. On battleships and first-class cruisers some efficient form of stretcher might be used to advantage if the bearers were thoroughly instructed and could be relied upon to handle them quickly.[10] But in the end, when all has been said touching upon the employment of stretchers in time of battle, we look to the lessons of actual experience for truth, and these seem to demonstrate their complete ineffectiveness. The numerous stretchers, slings,

FIG. 518.—WRECKAGE ON BOAT-DECK OF "OREL," FROM STORM OF EXPLOSIVE MISSILES (BATTLE OF JAPAN SEA, MAY 30, 1904). SHOWING DIFFICULTY OF GIVING FIRST AID TO WOUNDED.

jackets, chairs, and inclined planes, etc., devised and which have been tested and proved in peace times, when all conditions are favorable, fail miserably when called upon under conditions of stress. The heat and hurry and disorder of fierce engagements make their use impracticable and the comparative brevity of the engagements make it decidedly uneconomic of time, if not actually dangerous, to adhere to stereotyped methods of transportation. In default of these, the exigencies of the moment demand improvisations, but it is greatly doubted that any systematic attempt at transportation should be undertaken, and what little transportation is done to places of refuge and relief away from the tumult of guns must be accomplished by methods of hand carriage—one, two, or more bearers.[1] In the furious battle of the Yalu (1894-95) the Japanese discarded stretchers early in the day, the wounded being

carried below or to places of safety by shipmates, who took them pick-a-back or as circumstances indicated to be the most convenient and comfortable. The method of hand carriage, and that alone, will secure the expedition so desirable and necessary. But even this expedient is uncertain. There is no fixed personnel for the service, and bearers become more and more scarce in direct proportion as battles reach their height and the able-bodied men find their greatest need at the guns and in the fighting parts of the ship.[1]

The wounded, therefore, must in the main lie where they fall, as previously stated, and accumulate until there is either a summons for general relief or an abatement of operations, which give the surgeon's division an opportunity, or an end of the engagement. In some instances the mortality has been so high that the ship was obliged to withdraw from action and adjust herself to a diminished crew and to clear her decks of the encumbering wounded and dead.

The question of transportation after battle is an entirely different matter and will be discussed in its proper place.

SURGICAL CONDITIONS OF NAVAL WARFARE.[23]

General Considerations.—Projectiles rarely follow a rectilinear course, and there is frequently great doubt and perplexity as to the nature and direction of wounds on board ship from the variety of the bodies that are either directly projected from the guns or put in motion by the shells striking them, or from the fact that these are diverted in their course by the innumerable more or less resisting and deflecting obstacles.[19]

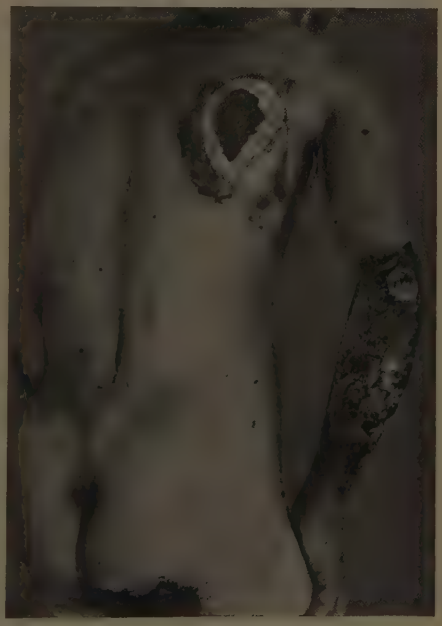

FIG. 519.—BURNS OF THE RIGHT SHOULDER, FOREARM, AND RIGHT BUTTOCK.

Nature of Wounds.—It is out of the question minutely to describe all the multiplicity of slight exfoliations, contused wounds, and burns; these must be omitted. They are the usual accompaniments of the larger and principal wounds, which latter have a wide range of variation, from the minuteness of a pea, such as are inflicted by small-caliber bullets, to the mutilation of the whole body. Within these extremes of degree wounds may be of any nature, including deep contusions, with visceral or bone involvement, blind wounds, penetrat-

ing wounds, and lacerated wounds of greater or less extent, with loss of tissue. Some are accompanied by fracture or dislocation, or both may be present; limbs and other parts of bodies are torn away; bones protrude through the flesh; and the soft parts deep down into the muscles are clipped out clean by shell fragments.[5] Indeed, a grave complexity of wounds, all simultaneously received, is not uncommon, and along with this frightful mutilation and laceration there is burning and charring of greater or less extent, due to the fact that the checked force of impact and bursting produces a dull red heat in the fragments of shells.[24] Structures of the most vital importance, such as vessels and nerves, narrowly escape, if they are not actually frequently involved, and all these complications illustrate the concomitance of the composite injuring elements in exploding shells. Indeed, no language can portray the infinite variety and horrible gravity of the wounds of naval warfare. The small-caliber bullet inflicts wounds which *per se* are more often aseptic than septic, and, furthermore, it seldom carries with it into the tissues clothing or other infected material. In these respects the army has distinct advantage over the navy, as most of our wounded suffer the larger, almost invariably infected wounds of shell fragments and other irregular missiles.[25]

FIG. 520.—RUSSIAN PRISONER; TYPE OF NAVAL WOUNDED.

Cause of Wounds.—Ordnance is tending to fight at longer and longer ranges, and in time there will be very little use for smaller caliber rapid-fire guns in a sea-fight between modern battleships. This change is in part attributable to the perfecting of torpedoes and the increased range of their effectiveness. The larger calibers have tremendous penetrating power and are being exercised with a rapidity and almost automatic regularity of fire, precision of aim, and accuracy of range, which guarantee the maximum destruction and create the most serious possibilities, nay, probabilities, as to the number of wounded. Furthermore, the shells are charged with modern high explosives, which upon exploding scatter a multitude of irregular fragments varying in number from twenty to fifty pieces[26a] and form a destructive area[5] that in reported instances has reached from fifty to one hundred men and more.[12] The greater the fragmentation of shells, the greater will be the number of men hit and the

more wide-spread the results; but, as a necessary consequence, the intensity and gravity of the individual wounds will be lessened.

By far the greater proportion of injuries and wounds result from shells, as such, and their fragments, when they explode, or indirect projectiles, like splinters of metal and wood from divers parts of the ship's structure that have been transformed into vulnerating bodies by the prodigious driving-force of a striking shell. The ignition of exposed ammunition placed at the guns or piled up at magazine entrances by shells or back-flares; bursting of imperfect guns; boiler explosions and scalds; and falls caused by shock or vibration, are all frequent sources of wounds, injuries, and wide-reaching disaster. Not the least among these collateral or secondary causes of injury is what has been termed blast-concussion. Several of these considerations of secondary injuring effects are dependent upon actual gun-fire under stress of belligerent action—others not, though they are intimately connected with the exalting influences of warfare. Happily the danger of boiler explosion and bursting guns becomes less and less frequent as construction is perfected; and as the possibility of other accidents appears, necessary precautions are formulated and enforced,

FIG. 521.—FRAGMENTS OF SHELLS EXTRACTED FROM WOUNDS OF RUSSIANS AND JAPANESE; ACTUAL SIZE.

1, Fragment extracted from calf of right leg, which inflicted large lacerated wound, fracturing both tibia and fibula; 2, fragment extracted from back at left side of tenth, eleventh, and twelfth dorsal, and first lumbar vertebræ; ribs mutilated and portion of the intestines and kidney injured; 3, fragment extracted from lower third of the right thigh through a counter-opening; 4, fragment which caused large flesh wound over nearly two-thirds of right arm, blind wound on the left iliac region, and fracturing femur; 5, fragment causing wound of left buttock, perforating wound of right thigh, and fracture of the femur; 6, fragment extracted from rhomboid muscles, which caused severe laceration of the left side of the shoulder with fractures of scapula; 7, fragment extracted by counter-opening, which caused wound on right shoulder, passing through upper part of scapula below clavicle toward the subclavian fossa and abrasion on the right cheek; 8, fragment extracted from large lacerated wound on left temple; 9, fragment which caused wound to the left buttock, passing forward and downward toward the front of the upper part of the left thigh; 10, fragment which caused wound in lower third of the left thigh, which was extracted by a counter-opening; 11, fragment which caused wound on the left parietal region, right arm, right forearm, and on upper part of the right thigh; 12, fragment extracted from wound on back of left forearm, also causing roughening of the ulna.

and mechanisms are improved or devices added through the ever-active ingenuity of officers, which reduce any given danger to a minimum. The "blowout" device now attached to big guns, which sweeps the bore clear of inflammable gases and débris before the breach is opened and prevents back-flares, is a fine example of the many inventions created by necessity.

FIG. 522.—FRAGMENT OF SHELL, ACTUAL SIZE, REMOVED FROM AN INJURED MAN DURING THE RUSSO-JAPANESE WAR (see No. 5 under Fig. 521).

Detailed Consideration of Wounds.—Character of Wounds Inflicted by Shells, as such, with Comments upon Amputation.—A shell failing to burst, or a solid shot intended only for armor-piercing purposes, produces most extensive and fatal injuries, for when a missile of this kind, at a high rate of velocity, strikes a part of the body directly, it carries all before it. "When a portion of a limb is carried away in this manner, the end which remains presents a flat stump nearly level, and much contused; the muscles on the face of the stump are crushed and lacerated and do not retract; the interstices in the tissues are filled with effused blood; splinters of bone and bone

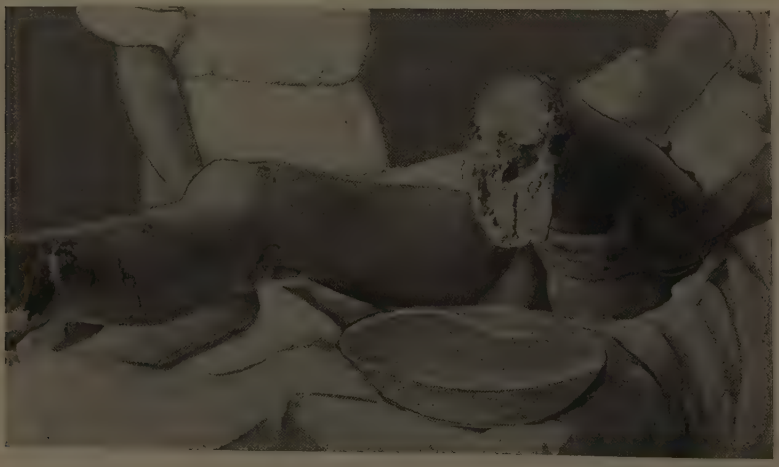

FIG. 523.—MUTILATED WOUND OF THE LEFT KNEE AND LACERATED WOUND OF THE RIGHT LEG.

dust are found on the far side of the stump, 'but the remainder of the shaft is not fissured or splintered.'"

"If, on the other hand, the force and velocity of an unexploded shell has much diminished before striking, a portion of the body or limb may still be carried away, but the condition of the injured part is somewhat different: the amount of laceration of the soft tissues is greater; the skin and muscles are more irregularly torn, and shreds or ribbons of these tissues hang from the wound; the muscles are more separated from each other and show signs of having been partly dragged out from their sheaths and intermuscular septa; the face of the stump, if a limb be concerned, is more jagged and uneven; the bone splinters seen on the exit side are larger; 'the remainder of the shaft is not so smoothly cut across, and fissuring and splintering occur in it to some extent' (Longmore)."[26a]

Wounds of this origin sometimes imperatively demand immediate operation, such as amputation. In cases of this sort particularly, judgment and not impulse should guide. The time that has passed from the instant of the wound should be taken into consideration, though this is not usually long. Hemorrhage, of course, permits no delay of the necessary procedures for its control, and in regard to other features of the cases, they should be cared for as soon as possible, because the men are still in an exalted condition, possessed of their full vigor and moral courage, and are better able to support the operation and its consequences. One should not go to the other extreme, however, and operate too soon. General or constitutional shock is usually well marked in cases of shell-wound, and if shock has occurred any interference beyond the requirements of first aid must be delayed until the pulse is again full and reaction has taken place. Amputations performed before the wounded have recovered from this injury to the nervous system are nearly always quickly fatal. The human system does not seem able to support these two shocks in close succession. It therefore requires a fine appreciation on the part of the surgeon as to the time which should elapse, and it is right to say that the number of cases which do not permit waiting are comparatively few.[10] As a further reason for delay we find conservative surgery affirming its principles with growing energy. "'Tis true indeed," says Moyle, "he is a good surgeon that can take off a limb dexterously; but he is a better that can save it and heal it."[22] This quaint observation in the year 1702 seems to have been a prophetic promise for the future

FIG. 524.—MUTILATION OF THE RIGHT ARM.

of naval surgery, as it was offered as advice to the naval surgeon of that period. Today the efforts of all surgeons, championed by the rules of asepsis, tend toward this end. It is recognized that the conserving of members does not expose one to the chances of death more than untimely amputation, and that where delay is not otherwise contraindicated there are distinct advantages in deferring these cases to a later period, when they then become operations of choice.[10] Anything like a set operation is, however, seldom possible, the condition and form of the injured tissues requiring special operations. It must be remembered, also, in contemplating any serious operation, that during times of hostility, whether actually engaged or not, a fighting ship is but an emergency hospital, and the sick and wounded will have to be transferred and must be kept in as good condition as possible for this further trial and discomfort.[10]

Character of Wounds Inflicted by Large Fragments.—Large fragments of shell have a comparatively feeble flying power and their

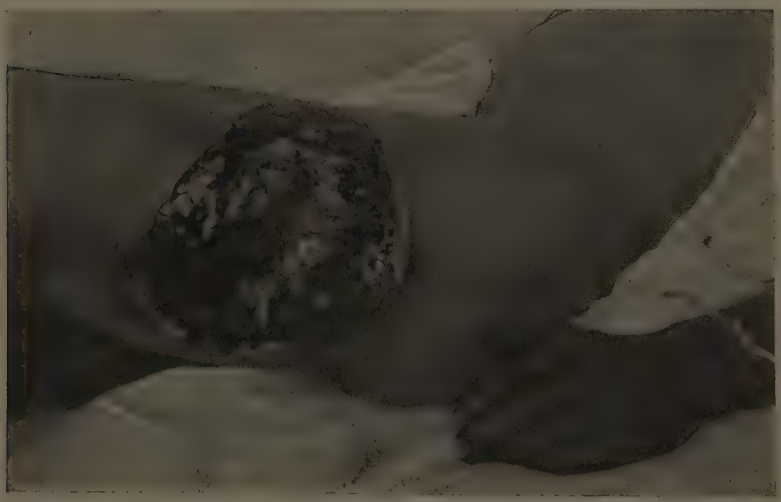

FIG. 525.—LACERATED WOUND OF THE LEFT THIGH WITH LOSS OF SOFT TISSUES.

ability to penetrate living tissue is not usually very great; they rarely perforate. Their irregular jagged shape, however, makes them vicious missiles and they contuse and lacerate the soft parts to an enormous extent. Their form and velocity, therefore, are best calculated to produce injury which is great in area rather than in depth. "Perhaps the most typical kind of wound produced by shell is that seen when a fragment has cut or torn its way into the soft parts and remains there, more or less buried, and it is remarkable what huge masses of metal are occasionally hidden away in this manner. The entrance wound in the skin is nearly always smaller than the cavity in which the missile lies, and it is often difficult to account for the passage of so large a piece of metal through so small an aperture. The sides of such a cavity in a badly lacerated wound do not show much tendency to come together when the foreign

body has been removed, as the parts are so devitalized and torn by the searing influence and force to which they have been subjected that they are incapable of resuming their original relations to each other."[26a]

When a part of a limb is carried away by an unexploded shell, or a severely lacerated wound is produced by a large fragment, although some time after the occurrence of the injury there may be no sign of contusion and ecchymosis of the surface in the immediate proximity, yet these will sooner or later show themselves in a very marked degree; the condition of the parts after a day or two will be exactly as though they had been directly injured, and a knowledge of this fact will affect the question of primary amputation and the situation at which it should be performed.[26a]

Character of Wounds Inflicted by Small Fragments and Splinters.—Most wounds caused by the penetration of small fragments or splinters of material from surrounding structures are blind, and the former missiles may be taken for granted even though not seen, when the wounds have reached the deeper parts of the body.[23] Multiple small scattered wounds are also noted as a result of a shower of these small fragments. It is this class of wounds which represents the greatest likelihood of containing infecting substances. When near important regions of the body these wounds require very careful examination, in order that the danger of overlooking extraneous matter may be excluded. The early consequences of neglecting this injunction vary with the region of the body concerned; the remote sequel is avoidable fatality.

FIG. 526.—LACERATED WOUNDS OF THE LEFT EYE AND LIPS, WITH LACERATED WOUNDS OF THE RIGHT THIGH AND LEG, AND FRACTURE OF THE LOWER JAW.

The general management of all shell-wounds is in accordance with common sense and the requirements of modern surgical methods; strict asepsis or, better, antisepsis must be observed, and as a cleansing, soothing, and recreating lotion, warm normal saline solution is particularly useful. The surrounding skin is to be disinfected and all extraneous bodies, as fragments of metal, splinters of wood, rags of cloth, and sand, etc., or substances accidentally foreign, as coagulated blood, hair, pieces of bone, and detached flesh, etc., are to be extracted; severed blood-vessels are to be ligated and injured nerves and tendons repaired; in

wounds having regular edges and in which the damage to underlying tissues has not been great, sutures may be tried, but in deep large irregular ones in which, exclusive of considerations for the almost certain infection, any approach to healing by first intention could not be expected, drainage-tubes must be introduced and the area of exposed raw surface reduced by approximating edges and binding detached integument to underlying tissues with bridge and tack sutures. Blind wounds with small inlets must be enlarged for convenience of examination and the removal of foreign bodies, and at the same time with a view to preventing any accumulation of discharge afterward.

Regional Wounds.—As most persons injured generally show several wounds, any classification of the seat of injury is more or less arbitrary, and the tabulation must be according to the most severe wounds.[13c] Statistics for recent naval battles show that the number of injuries caused by projectiles, arranged according to locality, except

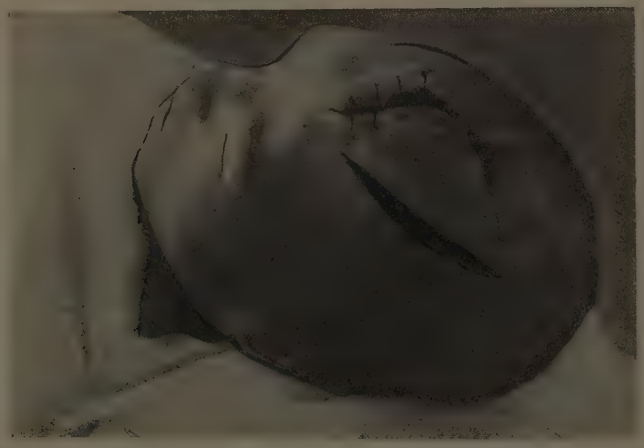

FIG. 527.—COMPOUND FRACTURE OF THE FRONTAL BONE.

complete destruction of the whole body and extensive burns, is greatest in the region of the head; then, in order of frequency, the lower limbs, the upper extremities, the abdomen and lumbar region, the chest and back, and, last, the neck.[13a]

Wounds of the Cranium.—Some of the most disconcerting and difficult cases are those with wounds about the head and face. "The destruction of tissue and disfigurement is often frightful, as where a man has the jaw shot away or the outer wall of the orbit blown off, leaving the eye and its attendant nerves and muscles exposed to view."[42a] The cranium may be completely crushed, with pulpification of the encephalon, or it may sustain any variety and degree of fracture in one or another of the cephalic regions—basal, occipital, frontal, parietal, or temporal. "The inner table of the skull, as a rule, is liable to be broken more widely than the outer, and, accordingly, it is not infrequently found that the former is injured when the latter is intact."[13a] "It is hardly going too far

to say that as a general rule of surgery, it should be understood that all ..... injuries of the head in which there is evidence of actual contact of the projectile with the bones of the skull require operative interference (sooner or later) to give them the best chance of recovery."[26b] The visible injury is no criterion of the real damage which may exist within, and though at the time there may be no signs of cerebral injury or of intracranial hemorrhage, the necessity for operation should not be seriously or long doubted.

Wounds of the Spine.—Spinal injuries, such as dislocation, fracture, and concussion, are frequent, and portions of the vertebral column may be carried away and otherwise badly mutilated. The management of these conditions must conform to well-established rules. Further than this, it need only be said that where the extent of damage is not obvious and pressure symptoms survive the recovery from shock, no time should be lost in resorting to laminectomy or other operations indicated for relief, as the process of nerve degeneration instituted by the injury will extend as long as the cause is permitted to act, and the ultimate result will be by just so much impaired. If the cord is severed, it should be sutured if possible. Though this promises little, it offers the best chance out of an otherwise hopeless paraplegia.

FIG. 528.—PERFORATED WOUND OF THE FACE WITH FRACTURE OF THE SUPERIOR MAXILLA; PERFORATED WOUND OF THE RIGHT FOREARM AND LACERATED WOUNDS OF THE RIGHT SHOULDER AND RIGHT HAND.

Wounds of the Extremities.—The most common injuries to these parts, and, when they are not immediately fatal, the most formidable, are fractures in which the bones are crushed into numerous irregular fragments that are forced into the flesh, tearing and destroying the soft parts, blood-vessels, and nerves, producing a combination of all the complications that can render a wound severe and dangerous.[19] Recent naval battles, however, furnish evidence[13a] that even in apparently severe wounds the bones may suffer only superficial damage, the keen edges of a spent shell fragment injuring only its outer wall or plate. The question as to the advisability of amputation will certainly often arise, but its determination must rest with the individual surgeon. Many limbs can be saved by intelligent conservatism, but the life of the individual, on

the other hand, must not be jeopardized by such overweening confidence in the power of nature as will lead to errors of delay.[19]

Wounds in the lower half of the body call for the utmost solicitude owing to the vital structures concerned. Many of them are immediately fatal as a result of the contusion and shock incident to the infliction, and independent of the visible wound. Instances have been reported in which the abdominal parietes have been entirely torn away, leaving the viscera exposed and apparently intact,[27] but, as a rule, one or more of the viscera and the large blood-vessels are destroyed by the pieces of shell.[13c] The most common wound of the region is a penetration of the cavity, with more or less internal damage, and here the usual procedure for reaching and removing the missile, stopping hemorrhage, and repairing ruptures and tears of the hollow and solid organs must be followed.

FIG. 529.—BLIND WOUND, RIGHT SIDE OF FACE WITH FRACTURES OF SUPERIOR MAXILLA AND PALATE.

Wounds in the upper half of the body are comparable to those of the lower half in point of gravity. The sharp edges of the penetrating fragments cut and lacerate the lung tissue and often result in extensive hemo-pneumothorax,[42a] if nothing worse. The particular injunction to be observed in the care of cases of this class is that painstaking efforts must be made to find and extract a penetrating missile and the extraneous matter which may have been carried with it, as otherwise empyema or pyo-hemo-pneumothorax as a distressing complication will surely intervene.[13a] Suture of heart wounds may be attempted, but the moment of its urgency is usually so unfavorable to its successful accomplishment, to say nothing of the very dubious prospects of the ultimate results looked for, that one is rarely warranted in undertaking such an unavailing expenditure of time so valuable to others, who offer a surer response to emergency relief.

Injuries of the Eye.—Instances of rupture of the iris are on record, produced, it is supposed, by the sudden and forcible contraction of the muscles of the eye that the shock of a wound in the orbital vicinity occasions. These singular injuries usually terminate in cataracts.[19] The eye may sustain other direct injuries which require enucleation.

Injuries of the Ear.—The ear is subject to grave accidents peculiar

to the service. This delicate organ suffers more damage from mere gun-fire than any other part of the body, the vibrations being conducted to the labyrinth both by way of the outer and middle ear and through the hard bony parts of the skull, causing respectively the curable ruptured membrana tympani and the irreparable gun-deafness produced by repeated injury of the delicate nerve terminals in the internal ear.[29] Our immediate concern is with the former. This injury is effected by "explosion gas" (gas produced by the explosion of an enemy's shell close by) and vibrations of air consequent upon firing the ship's guns.[13a] Though often reported, it is believed to be much more common than records indicate, as most probably there have been many cases attended with rupture, among those killed on the spot or who died soon after, which escaped notice. When the tympanum rup-

FIG. 530.—LACERATED WOUND OF THE SACRAL REGION, WITH FRACTURE OF THE SPINE OF SACRUM.

FIG. 531.—PERFORATED WOUND OF THE LEFT ELBOW, WITH FRACTURE OF THE BONES; LACERATED WOUND OF DORSAL REGION WITH FRACTURE OF VERTEBRAL SPINE.

tures, treatment should at once be instituted looking to the avoidance of infection of the middle ear.[1] Of course, it is realized that this advice must fail of practicability during the heat of action, but the desirable end sought will be in a measure subserved by the prophylactic cotton pledgets distributed before an engagement. The further management of these cases need not be discussed here, but it may be safely affirmed that if infection is prevented the rupture will heal promptly by first intention.

Scalds and burns, unhappily of frequent occurrence, are usually injuries of great gravity in the navy, being the result of accidents of such magnitude as boiler or powder explosions. The latter cause is the

more likely possibility during hostile activities, but it has given rise to appalling accidents during target practice, such as the recent catastrophe on the U. S. S. "Missouri," when some thirty lives were lost. The "Bennington" disaster in San Diego Bay exemplifies the terrible possibilities from

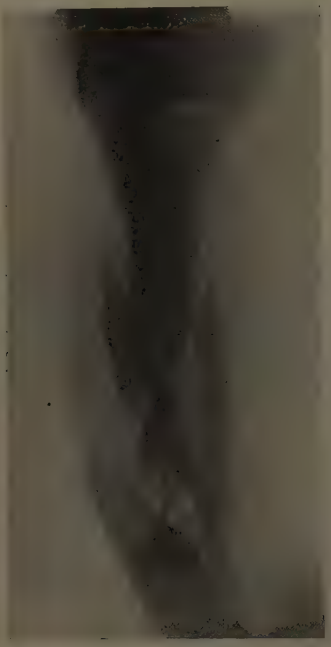

FIG. 532.—COMMINUTED FRACTURE OF THE HUMERUS.

FIG. 533.—MUTILATED WOUND OF THE RIGHT FOOT.

boiler explosions. Some suffer from burns pure and simple; others from serious accompanying wounds, and when, in the case of brown powder or cordite, the explosion occurs in a turret or other confined

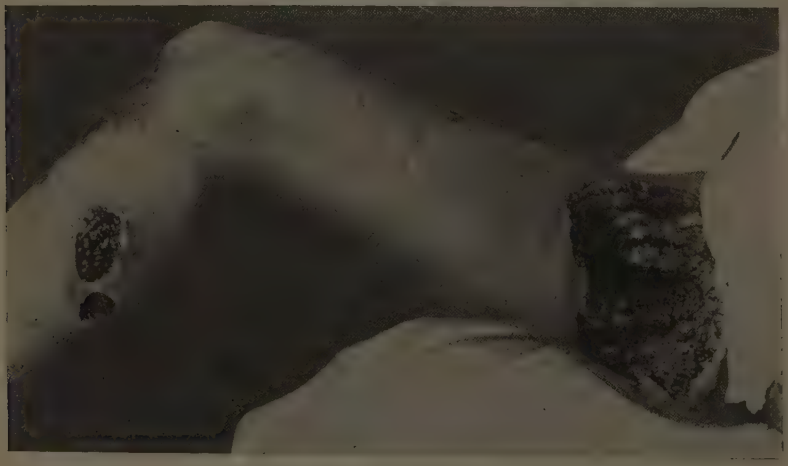

FIG. 534.—LACERATED WOUND OF THE RIGHT THIGH WITH LOSS OF SOFT TISSUES.

space, great pressure is developed as well as intense heat, which forces the gaseous products of combustion (carbon dioxid, carbon monoxid, hydrogen, nitrogen, and methane) into the tissues and is responsible for some of the effects produced.[30] Burns are very extensive, affecting not only the exposed parts, such as the face, neck, and hands, but as much as two-thirds to three-quarters of the entire surface of the body from the burning of the clothes.[13a] As a rule, they vary only in extent, their depth reaching not beyond the limits of the second degree, owing to the short duration of the flame. There are many cases, however, which exceed this average, and the blanched waxy appearance of the uninjured skin and mucous membrane, combined with the charred board-like hardness of the integument, split open in many places, attest the enormous damage and destruction that is produced. The burned area is generally blackened or browned by the fumes and the unconsumed powder, and the hair

FIG. 535.—GUNSHOT WOUND OF THE ABDOMINAL WALL WITH LOSS OF SOFT TISSUES.

is singed. Some are salivated, and all exhibit a huskiness of the voice as if they had inhaled the hot gases. It is probable that many suffer from the internal effects of the flame.

The **constitutional symptoms** vary to some extent, but in general follow rather a typical course. At first they denote great nervous excitation and apprehension, accompanied in some cases with night terrors. This may be succeeded, through reassurance, by a permanent normal mental state, or in the most serious cases may pass beyond into a condition of shock and collapse. Pain and thirst are intense. In cases where inflammatory reaction sets in the temperature rises in a remarkable manner, and the involvement of a considerable surface is usually attended with septic absorption. Necrosis and sometimes even dry gangrene are prominent among other complications.

The **treatment** must first be directed toward supporting life, relieving pain, and lessening shock. Morphin, iced drinks, and stimulants should be freely administered. The clothing must be cut and removed piecemeal so that there may be no undue pain inflicted in the operation, and, when necessary, the part or the whole body may be immersed in warm water to soften the adhering garments. The burned areas may then be quickly and gently cleansed of sloughs and exudations and enveloped in gauze wet with warm one-half per cent. picric acid solution, and this in turn covered with paraffin paper and retaining gauze bandages. Where the whole body is burned, it may be quickly and temporarily enveloped in a sheet wet with picric acid solution. With a view to lessening pain and discomfort, and the frequent exposure of raw surfaces required in the usual redressings, it is deemed more in consonance with all the indications that the following procedure be adopted: Each day, following the original

FIG. 536.—PERFORATED WOUND OF THE NECK.

FIG. 537.—LACERATED WOUND OF THE LEFT THIGH WITH LOSS OF SOFT TISSUES; BLIND WOUND OF THE LEFT FLANK WITH FRACTURE OF THE ILIUM; ABRASION OF THE LEFT FOREARM.

dressing, the bandages are removed and the paraffin paper rejected; but the picric acid gauze is left intact. The wounds are then irrigated through

the gauze by quantities of warm picric acid solution. This is continued until the solution passes away clear, when again paraffin paper and bandages are applied. On the fourth day the gauze is rejected, sloughs are trimmed away, and, after thorough irrigation, a new picric acid dressing is applied. So the cycle of dressings is continued until the exudate is materially diminished, when a dry powder dressing (aristol one part, boric acid three parts, reduced to impalpability), covered with foil or protective and ultimately secured by gauze bandages, can properly be employed. Later, when new skin has formed, some unguent may be used. Chloretone has been recommended[42a] instead of picric acid, but its value is still *sub judice*. In burns of the face scabs should be encouraged and only slightly raised for sufficient irrigation with hydrogen dioxid in cases of retained pus. Fingers and limbs should be splinted to prevent cicatricial contractions and passive motion begun early. Daily doses of magnesium sulphate may be administered with advantage as a theoretic antidote to picric acid in the event of its absorption and the formation of carbol urea.[32]

FIG. 538.—PERFORATED WOUND OF THE RIGHT CHEEK, AND LACERATED WOUND OF THE BACK WITH FRACTURE OF THE RIGHT SCAPULA.

Special Conditions and Constitutional Effects.—The naval surgeon is further concerned with a number of curious conditions incident to the development of:

Irrespirable Gases and the Concussions and Shocks of the Gun Discharges and Violent Changes in the Density of the Air within Confined Spaces.—For example, the rapid burning or explosion of smokeless powder, shimose, or lyddite, produces a complex gas which variously affects all who come within the radius of its influence. Some are suddenly prostrated in unconsciousness;[42a] others experience an exhilaration at first, followed by partial loss of consciousness. At least there are sensations of weakness, nausea, and asphyxiation.[16] The absorption of the compounds of nitrogen—nitrites and nitrous acid—is probably responsible for these symptoms. Recovery may be rapid, but it usually takes days before all symptoms have disappeared. Other effects of the inhalation of the products of combustion are those caused by the irritative action of gases on the respiratory tract. Œdema pulmonalis is one of the dreaded consequences.[31] Important in the list of these vague disorders and the one meriting special mention in this chapter is that commonly known as "blast concussion," which is produced among the men, particularly gunners, in greater or less degree depending upon their position

in relation to the guns at the time they are fired. This consists at first of more or less shock, involving the whole cerebrospinal axis, and a feeling of great depression in the epigastrium, followed by nausea. In some cases there is a vague mental disturbance accompanied by pain in the head. It is probable that the violent shaking suffered is due to the vibrations of the deck; while the abdominal symptoms develop as a consequence of the primary compression and secondary suction effect upon the body, particularly the unresisting abdomen, produced by the air displacement and immediately succeeding partial vacuum incident to the discharge of a large gun.[29] This condition is not ordinarily of great consequence *per se*, though capable of far-reaching results, but in that it conduces to the early development of surgical shock in those otherwise wounded.

FIG. 539.—BURNS OF THE FACE AND BACK.

Shock.—Nervous concussion or shock is often simultaneous with or immediately follows severe and extensive wounds.[9] Reliable observations would seem to agree on this general proposition, yet, even in this class of cases, the vitality and mental exhilaration of a combatant may not abate until the fight is over, and thus the full development of the condition may be long delayed. Indeed, the immediate constitutional effects of precisely the same kind of injury vary so much in severity and duration and are so totally different in different individuals that no description can be given to cover them all. Traumatic delirium, occurring in those wounded in the neighborhood of the explosion of large shells,[13a] and paralytic insanity consequent on lesions of the sensory and motor centers, are among the forms noted. Some men pass into a state of profound shock from unaccountable fear which the bravest cannot resist or conceal, and which nothing will abate; while others manifest not the slightest depression or alarm, though suffering the gravest injury. It is not a matter of courage, but is purely temperamental.[19] If only nervous in origin, the case will in all probability react soon under proper stimulation and the relief of suffering by such means as splinting broken bones in severe injuries; but if dependent upon loss of blood, immediate attention with stimulants and transfusion or saline injections can alone prevent a fatal issue.

Hemorrhage.—All wounds are attended with more or less hemorrhage,

and this, with pain in the first stage, is nothing more than an inevitable initial symptom.

Primary hemorrhage in most wounds in naval warfare is comparatively slight at the time of injury, owing no doubt to the lacerated and contused character of shell wounds and the weakened action of the heart incident to shock. Steps to arrest hemorrhage are only occasionally necessary, and it will usually be found to cease of its own accord.[13a] It may be useful to observe as a pertinent warning that the indiscriminate employment of a tourniquet in wounds is often extremely prejudicial. The instrument is seldom required in naval actions except in wounds of the large arteries and in operations, and everybody who is instructed in its application as a first-aid measure must also be *cautioned against its use unless obviously required*. The fear of hemorrhage is the greatest dread of seamen, and whenever they are allowed tourniquets they apply them in all manner of wounds. The bleeding stopped, the patient, fancying himself perfectly safe under the protection of this "gigantic fiend," creeps into a corner, where he is not discovered till the ligature has caused the most direful effects, and the otherwise simple wound has been rendered highly dangerous. Sometimes it becomes necessary to postpone operations in consequence of swelling and inflammation produced by this instrument where its application was not required.[27] The vascular tissues share the nature of the wound of the surrounding structures, being more or less contused above and below, and when vessels are rent the order in which their coats give way generally facilitates the coagulation of the blood. These statements are, of course, of a general nature, and do not express the truth in all cases, for profuse and dangerous primary hemorrhage does occur, particularly when the large vessels are involved and the injury is of the nature of a perforation or half rent, so that the inner and middle coats are not permitted to curl up and favor coagulation.[13a] The principal arteries of the thigh and arm are too large, even though torn asunder, to form enough coagulum to stop hemorrhage quickly, and death will speedily ensue if the bleeding is not immediately staunched by tampon or tourniquet. Even then the loss of blood will still be great. However, in the surgical history of recent naval wars comparatively few deaths are attributed to primary hemorrhage.

But there is great danger of *secondary hemorrhage*, as the devitalization of tissue in shell wounds is so extensive and deep that sloughing almost always takes place and will involve the vessels which have been contused or lacerated.[13a] The possibility of serious consequences from this accident are, however, greatly reduced under the watchful care of a good nurse during the relative quiet of after-battle conditions. The Japanese reports bear out this conclusion.

Treatment.—The management of hemorrhage is so important a question to military and naval surgeons that any method of treatment which is at once safe and available and rational should be eagerly welcomed. Valuable experiments with a view to finding a means of successfully treating the grave hemorrhages which our present methods cannot relieve are continually being conducted. Crile and Dolly are among the late

investigators along this line, and they offer conclusions well worth considering and quite within the possibilities of naval practice. Indeed, the method of man-to-man transfusion recommended is especially available to naval surgeons, for there is no class of men in which the spirit of comradeship and humanity is so highly developed as among seamen. It is not feasible or necessary to enter into a discussion of the principal resources for treating the conditions; these are given in detail elsewhere. Suffice it, that all, though they hold an undenied place, are for one reason or another unsatisfactory, and "the biochemic researches of recent years have demonstrated the old method of blood transfusion to be inapplicable."

Prognosis and Complications.—The **condition and progress of wounds**[23] will depend entirely upon the length of time which elapses between the moment of their infliction and the hour and character of surgical attention rendered. Where immediate thorough attention is given, even large wounds may heal kindly and comparatively rapidly, allowing for the very natural inflammatory reaction to the contusing force, which appears as a reddening at the margins of the wound and slight suppuration. Small contused and perforated wounds will often heal without any sign of inflammation or suppuration when early protected by an emergency dressing. In the larger, deeper wounds and those vast lacerations so frequently encountered, however, the process of healing, even with the utmost care, is sure to be slow, and the course will be marked by sloughing, suppuration, and possibly secondary hemorhage. The minutest scrutiny sometimes fails to discover all foreign bodies, and gradually small pieces of clothes and particles of crushed bone which are not extracted will come away with the putrefying tissue. Healing must be by granulation; in fact, by that process which modern surgical technic tries to prevent, and which is so often accompanied by fatal surgical infective disease.[26a] Fortunately, the very openness of the wounds secures free drainage and facilitates thorough cleansing, so that septic intoxications are not necessarily imminent, and the temperature curve followed by these cases is usually low, unless some complication, such as erysipelas or tetanus, supervenes. Nevertheless in all cases of shell wounds, however slight they may at first appear to be, the prognosis should always be a guarded one, as the patient will have many risks to run.

Suppuration, as previously indicated, is the rule in the extensive and grave injuries of naval warfare, in spite of ample provisions before and the utmost care during and after engagements to prevent it. The very nature of the wounds—their irregular surface and edges and impaired vital resistance—insures the seclusion and rapid growth of micro-organisms when once they have invaded, and it cannot be held that there is any paucity of septic possibilities or sources. The condition of the individual's skin; his clothing; the great variety of substances that may be carried deep into the tissues with the wounding missiles; the inadequacy of the temporary surgeries from an aseptic point of view; the darkness and poor ventilation of a ship battened down for battle; and the continual agitation of the ship from the gun-firing, which keeps everything covered

with the dust and dirt of an engagement, give ample opportunity for wound infection.

Gangrene.—Sloughing of the tissues around the wound is a common stage of all shell wounds, and distant gangrene, through injury of the main arteries with their complete obliteration as blood channels and the formation of emboli which plug the collateral circulation, is a grave possibility, though not as frequent in actual experience as might be supposed. In the war of 1904-05, for instance, out of two hundred and fifty-six wounded only three cases of distant gangrene were noted.[13a]

Erysipelas and tetanus, while happily rare, must nevertheless be considered constant dangers, and in recognizing the possibility, every care must be taken that the ship is in as good sanitary condition as the unavoidable circumstances of the engagement will permit, and to remove the wounded off the ship as soon as the transfer can be effected. With the standard precautions of the present day there will be little danger of an actual epidemic.

Considerations Affecting the Ultimate Outcome.—After careful attention to the wounds themselves nothing is more important in the further management of the cases than good food, light, fresh air, and a cheering influence. The favorable course of convalescence and ultimate recovery will in a great measure be determined by these considerations. The buoyant spirits which victory occasions will, *cæteris paribus*, insure the surgeons on the conquering side more success than those who have charge of the vanquished crew.[33] Above all, in caring for the wounded the surgeon must never abandon hope, never take for granted that death will inevitably follow in any case, however desperate, for many recoveries are recorded in seemingly hopeless cases. A belief, founded on all ordinary and rational calculations, that nothing that can be done will be of avail, is so discouraging, and so apt to paralyze exertions that it should always be the endeavor to bend convictions the other way as a spur to the most enthusiastic and sanguine efforts.[19]

CONDUCT OF THE MEDICAL DEPARTMENT AFTER BATTLE.

As has been previously intimated, the final thorough care of the wounded must not be long deferred. If for any reason the wounded are not transferred to a hospital ship or ashore soon after battle, all requirements must be met on board ship with the utmost care and conclusiveness.[23]

In any case the cessation of hostilities is the signal for the beginning of the surgeon's real hour of usefulness. The wounded given first aid and the battle ended, his mission, so far from being accomplished, requires renewed activity. Now he can have control of the ship as far as space and free hand are concerned, and can substitute comparative order and comfort for the rough treatment or neglect which the previous hurried maneuvers necessitated. The galley and bakery are placed at his disposition for the sterilization of additional dressings and instruments and the preparation of an abundance of hot water. Plenty of unskilled aid is forthcoming without the asking. Everybody turns from the business

of war to the tender duties of succoring the wounded, and the surgeon, guiding and directing these humanitarian energies, and seeing as far as possible that all cases are properly prepared for transportation, reigns supreme below the bridge. The sick bay with all its conveniences, if not shot away or demolished, becomes in this phase of the surgeon's responsibilities an invaluable accommodation, and various other compartments now become available for the care of the wounded to take the overflow from the sick bay. Cases are taken below in order of their gravity, and everything needful is done for their comfort, the safety of their lives, and in preparation for prompt and efficient transfer. At this time, also, the names of the wounded and the nature and gravity of their lesions must be carefully noted in order that an exact report can be rendered to the captain.

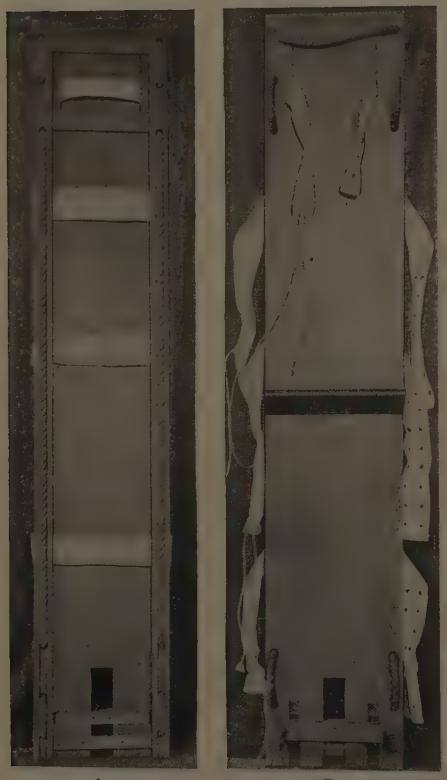

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FIG. 540.—TRANSPORTATION BOARD, (A) BOTTOM AND (B) TOP VIEW.

METHODS OF TRANSPORTATION.

Stretchers in General.—After battle the transportation of the injured is a question for less hasty decision, and the selection of suitable ambulance methods becomes at once a difficult and important matter. Of course, in all deliberations upon this subject, and in the exercise of ingenuity in design and construction, the nearer the approach to actual battle requirements the better. Studies and investigations along this line have been so untiringly and painstakingly conducted that again and again it has been thought researches have been brought to a point where they could be abandoned (the "inclined plane" of Marechal, the "sliding bar" of Stitt, and the "ambulance lift" of MacDonald, are examples), but the progressive substitution for contrivances formerly employed silently, one by one, proclaims their imperfections. There are a few such which have not yet been entirely laid aside, as incorporating so many good features that their disadvantages are almost negligible, and they will continue to claim a considerable place in the performance of transportation until the newer ones prove their superior capacity and more

versatile adaptability. "The transportation board" occupies a unique position in this respect, and for years, and until the approval of the report of the recent joint Board of Army and Navy Medical Officers, was the official stretcher in the United States navy. In spite of the danger of splinters and its weight and consequent clumsiness, there will doubtless be occasion for its use.

Difficulties Involved.—"Unless one has been on a modern man-of-war and examined its interior construction, he can have no correct notion of what the naval surgeon has to contend with in his care for the injured. With its massive machinery, its tangle of pipes, conduits, wires, rods, and hoists, its labyrinths of compartments, its maze of long, narrow, and often tortuous passages, its hatchways leading down to depths or opening up to lofty elevations, it is confusing in the extreme. . . . There are coal-bunkers into which men go, work, and are sometimes injured, the only exit from which is through a circular opening 20 inches in diameter. There are military tops many feet from the deck in which men are stationed in time of battle, and while there they may be severely wounded. Access to and from these tops is through a small aperture in their floor and down many feet by perpendicular ladders, and over bridges and various platforms. There are firerooms from which the only means of egress, especially during an engagement, is a perpendicular ladder twenty or more feet in height,"[8] and so on *ad infinitum*. The complex structure and multiplicity of barriers offer many unavoidable obstacles to the easy and favorable handling of the injured, and the difficulties often become embarrassing.

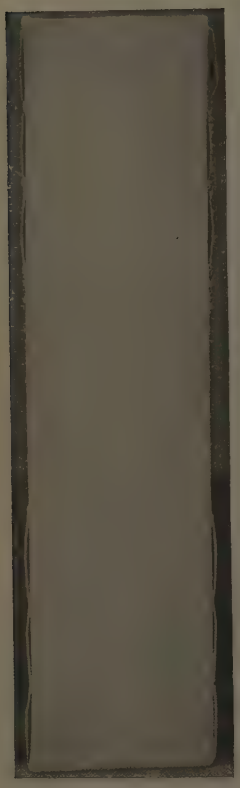
FIG. 541.—TRANSPORTATION BOARD IN USE.

Necessary Features of Stretchers.—"Wherever the patient may be at the time he received the injury, the time will come when, either during or after the engagement, he must be moved elsewhere; it may be to some other part of the ship or to another vessel, and on the manner of his removal will depend in a large degree the question of his recovery. Thus special methods are demanded and the ingenuity of the naval surgeon is taxed to the utmost. Probably the stretcher that will meet all possible conditions will never be constructed, since the difficulties, particularly on a battleship, will always remain in a degree superior to the cleverest contrivances."[8]

In intelligently undertaking the solution of the problems involved in the exacting and broad requirements of a battleship stretcher the inventor must calculate upon the very worst contingency possible, in both point of injury and path of traject, and be prepared to meet the needs of a particular case in a surgical manner. Of course, it must be constructed

so that it will readily conform to the conditions that prevail where it is to be used, and the other required features may be enumerated as: lightness in weight; strength; economy in storage; cheapness in construction; cleanliness; rapidity in securing patients; and adaptability to varied conditions or requirements.

There are two stretchers now used in the United States navy which conform rather accurately to these specifications: the "Stokes splint stretcher" and "the apron stretcher" of Lung. These are comparable



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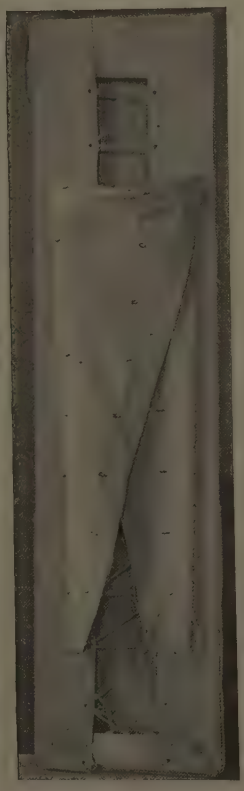


B

FIG. 542.—APRON STRETCHER, (A) BOTTOM AND (B) TOP VIEW.

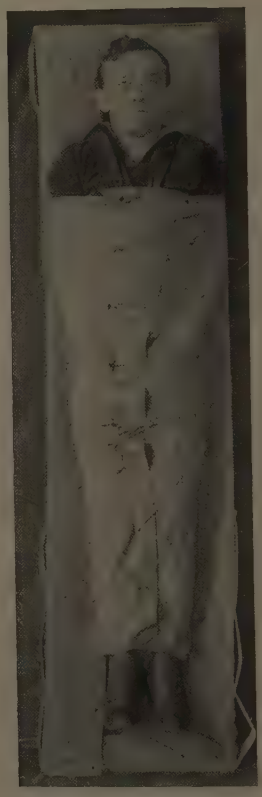


FIG. 543.—APRON STRETCHER IN USE.

in meriting approbation on the grounds indicated, and each includes additional special peculiar features beyond the standard requirements. There can be no doubt that both are well adapted to the purposes of battleship transportation and admirably meet the difficulties involved with a completeness which none before them can claim. As between these alone, therefore, should it be admissible to indulge a preference. The "Stokes splint stretcher" has been designated the official stretcher for the navy, but for convenience the "apron stretcher" will be described first.

"In general **'the apron stretcher'** may be described as follows:

"Over a light ash frame is stretched a canvas covering or bag. One side and end of this covering is left open so as to allow the frame to be introduced, after which it is tightly laced up. This combination of ashen

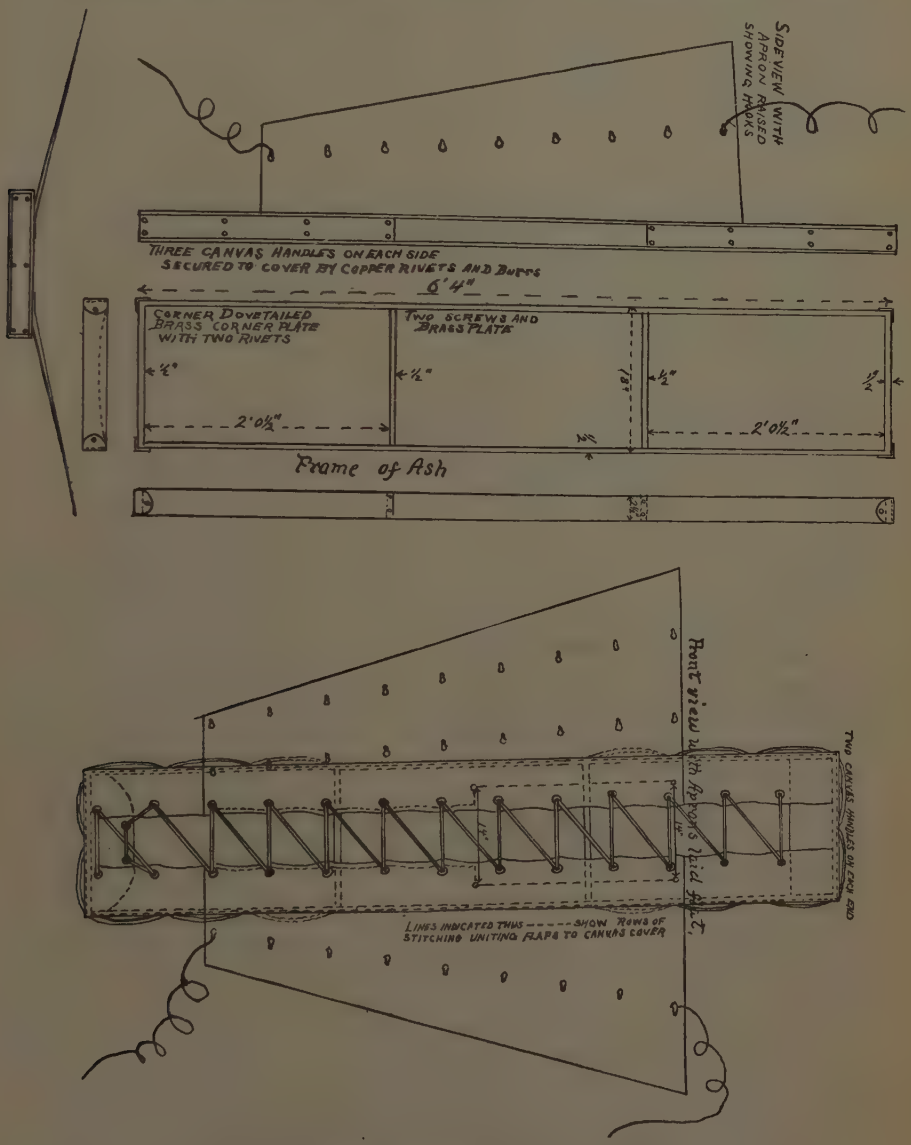

Side view with apron raised showing rivets
Three canvas handles on each side secured to cover by copper rivets and burrs
6'4"
Corner dovetailed brass corner plate with two rivets
Two screws and brass plate
½"
2'0½"
Frame of Ash
Front view with aprons laid flat.
Two canvas handles on each end
Lines indicated thus ----- show rows of stitching uniting flaps to canvas cover

Fig. 544.—Apron Stretcher, Working Drawing.

frame and canvas cover constitutes the splint base, locally soft and yielding to the body, but structurally strong and rigid.

"To each side of this covering is secured a flap or apron as indicated in the drawings, which are folded over the body of the patient from his

axillæ to his ankles, if need be, and then secured by hooks and lacings, quickly fastened in the same way as the ordinary shoe-lace is fastened. At both ends and a part of the length of both sides, handles are placed by which to grasp and lift or suspend the apparatus.

"In securing the patient to this stretcher his arms may be left free, thus adding to his sense of comfort, and he may be able to assist a little in his own transportation, or one or both may be included in the apron fastening."[8]

Before lacing up the apron, if it appears desirable, splints, cushions, or padding of any kind may be included, and it is maintained that the stretcher is adaptable to any injury, no matter what its nature, and that all cases can be transported with safety and comfort to the patient and ease for the carrier. Its peculiar recommendation lies in the facts that the material from which the frame is constructed is so disposed that it will not splinter and thus inflict further injury if struck by a missile and that the space within the frames and under the canvas covering may be used for carrying light articles, such as surgical supplies. The loaded stretcher may be handled by block and tackle or whip, and patients may be hoisted thus from one deck to another or from one ship to another with perfect security and evenness of support.

The **"Stokes splint stretcher,"** as stated above, combines all the standard requirements which recommend it to naval purposes, including simplicity in construction and freedom from the danger of contributing to the list of vulnerating missiles by being splintered. Its commendable and invaluable peculiarities lie: first, in the splint feature, which is so devised that fractures may be handled—not merely in a makeshift manner, but according to approved surgical methods; second, in the longitudinal braces which serve as runners when it is used as a sled; and, third, the sanitary opening, which meets an important need in those exceptional cases of prolonged retention in the stretcher.

For a detailed description the reader is referred to the inventor's original article.[51b] The illustrations (Figs. 545, 546) show the character of the stretcher sufficiently well. It is enough for immediate purposes to know that the frame of the device is of one-half inch galvanized steel material, which insures rigidity and strength; the body is wire netting sufficiently pliable to be shaped to the part it contains, yet rigid enough for effective splinting, and with a mesh sufficiently wide to pass a bandage at any part, so that after the netting has been shaped to a part it can be fixed there and an extremity secured as firmly as required. Two wide bands of canvas, one at the height of the axillæ, the other at the point of the hip, secure the thorax and pelvis respectively. The foot-piece consists of a shoe-shaped piece of galvanized steel somewhat wider than the foot, with a linear slot on each side for the passage of the securing bandage. It is secured to the mesh at any point by three rigid snap-catches, and it can be raised and lowered in the leg gutters at will. When not in use, it can be turned flush with the sides of the leg gutters, and snapped into the mesh in that position. It is considered a very important part of the apparatus. In the two leg gutters we have two wire gauze splints

and with the adjustable foot-piece two complete fracture boxes as well. The device weighs about twenty pounds, is eighty inches long, twenty inches wide at the shoulder, and eight inches deep throughout. The dimensions vary from this largest size just enough so that the stretchers may be nested in sets of three, requiring comparatively small stowing space.

The splint stretcher has maintained its prestige through a long series of thorough tests, and its adoption by the army and by the navy for ship use is ample evidence of its superior merits. "It can be used as a

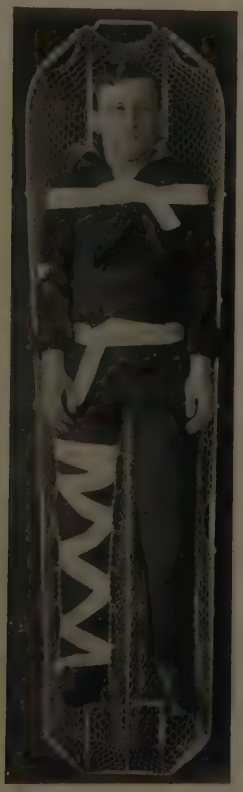


FIG. 545.—SPLINT STRETCHER IN USE.

A B

FIG. 546.—SPLINT STRETCHER, (A) BOTTOM AND (B) TOP VIEW, ALSO NESTED.

stretcher, as a sled, and can be slid down ladders from one deck to another with little or no discomfort to the patient. Supported by a tackle hook, it can be up-ended with ease, and in that position a patient can be safely put over the side or be sent below through hatches. When the splint stretcher is in a perpendicular position, the patient can keep away from the perineal fold by putting his weight on the foot-piece on the uninjured side. In case both legs are injured (or the patient is otherwise beyond helping himself) a bandage passed behind the neck over the shoulder and under the arms, and secured to the mesh, clears the perineum."[51b]

In all of these different forms of transportation the splint stretcher gives a sense of perfect support and guarantees safety and comfort as well as the best attainable surgical results. A drill adapted to its use for one, two, three, and four bearers has been formulated and is now being taught at the Naval Medical School.

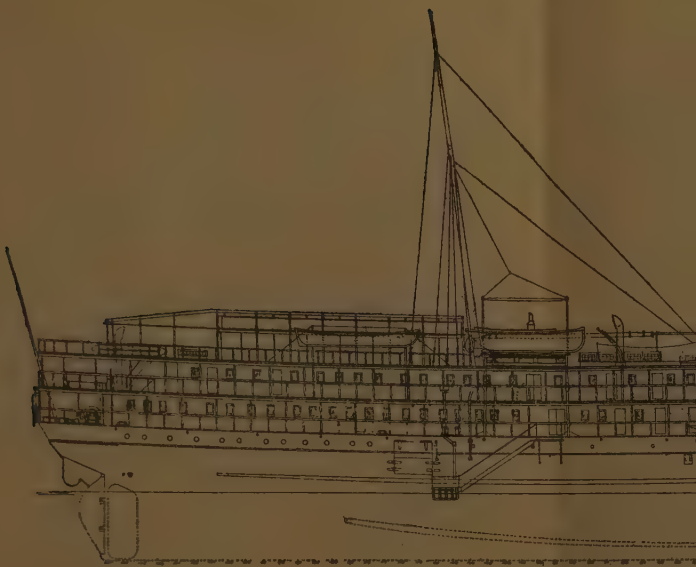
HOSPITAL SHIPS.

General Comment.—The idea of hospital ships as integral units in our fleets is by no means a new conception. The possible services of such an auxiliary in peace and war were recognized at a period long antedating their adoption, and while their importance is conceded by all

FIG. 547.—U. S. S. "RELIEF" (HOSPITAL SHIP).

countries, they have probably not yet reached their highest perfection, or unquestionably established their position in relation to belligerent forces—indeed, they have hardly been accorded a fair opportunity to establish their right of presence on all occasions of the larger movements, in spite of the fact that arguments for their existence are both humanitarian and military. One of their most important functions has, however, been definitely settled through experience in the wars of 1894–95, 1898, and 1904–05; viz., their attendance upon naval engagements; and as this, by its very nature, embraces the necessity of their presence in squadron in times of peace, if for no other purpose than drills, we must believe that their ultimate complete recognition is assured.

Hereafter in naval wars the hospital ship will continue to be an in-



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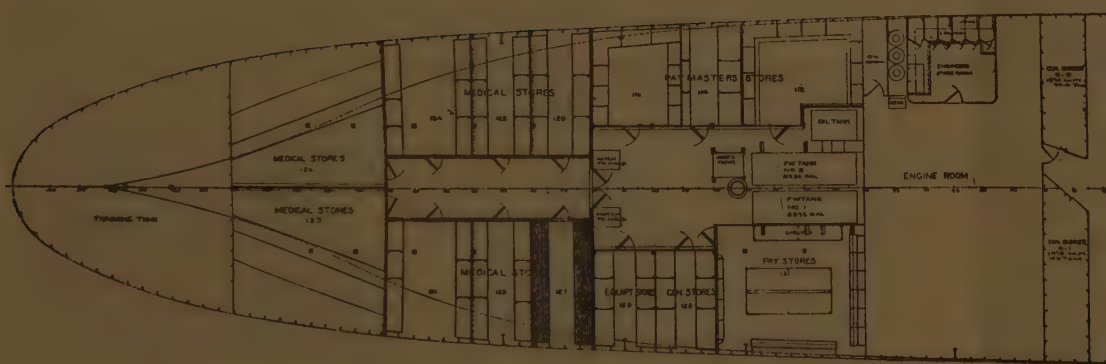
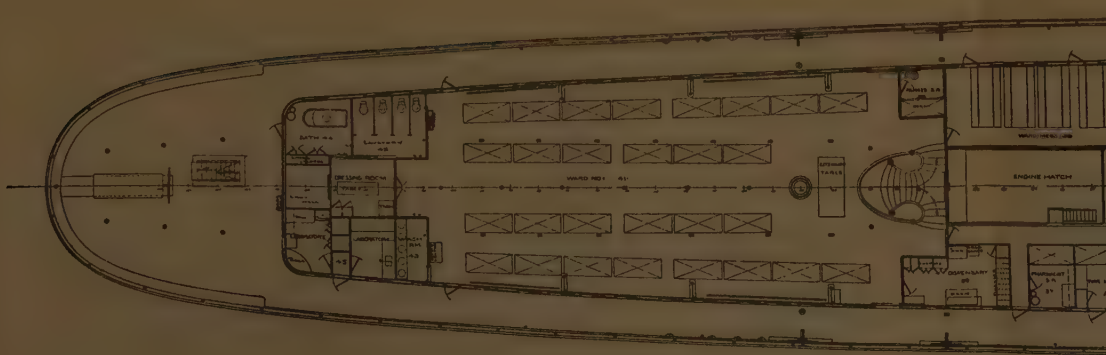


PLAN OF PLATFORM



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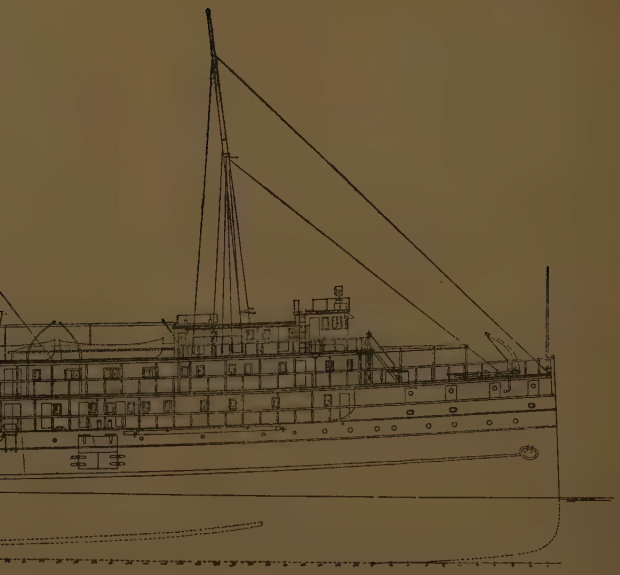
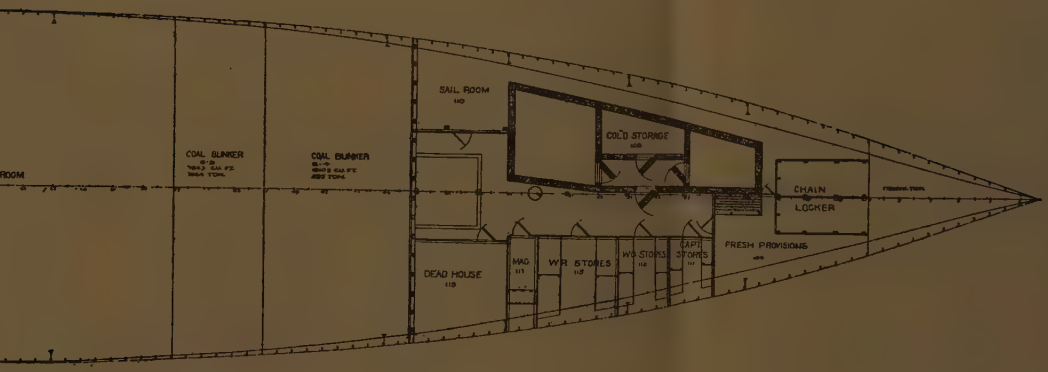
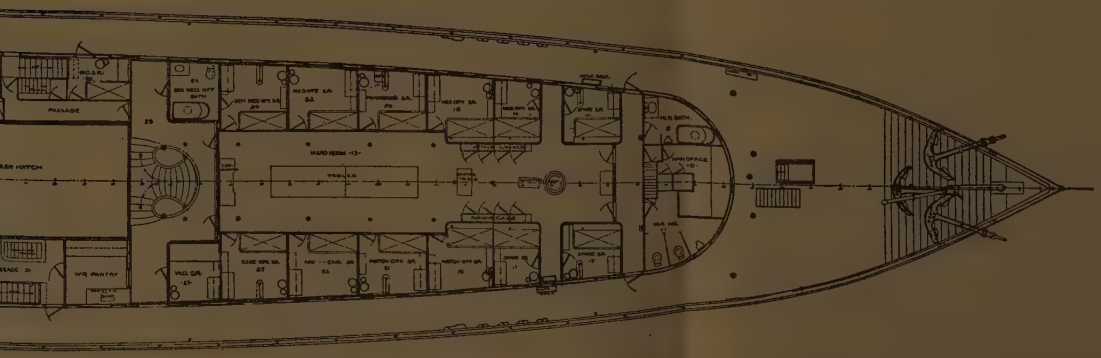


E, U. S. S. "RELIEF."



OLD, U. S. S. "RELIEF."



S. S. "RELIEF."

creasingly essential part of the properly organized fleet, and the old-time practice of retaining and imperfectly caring for the seriously wounded on board the fighting ships by this means may be exchanged for removal to a vessel flying the Red Cross flag and fitted with every modern appliance for life-saving and the comfort of the stricken.[13b]

Furthermore, this transfer to hospital ships becomes imperative for military reasons, and it should be effected as soon and as often as opportunity occurs, so as to leave the men-of-war unhampered and fit to engage the enemy at the shortest notice and under the most favorable circumstances.[46b] In the future movements of the ship the captain must consider the number of wounded, even though the number is not so great as seriously to embarrass navigation.[28] The circumstances of naval

FIG. 548.—BERTH-DECK WARD, U. S. S. "RELIEF."

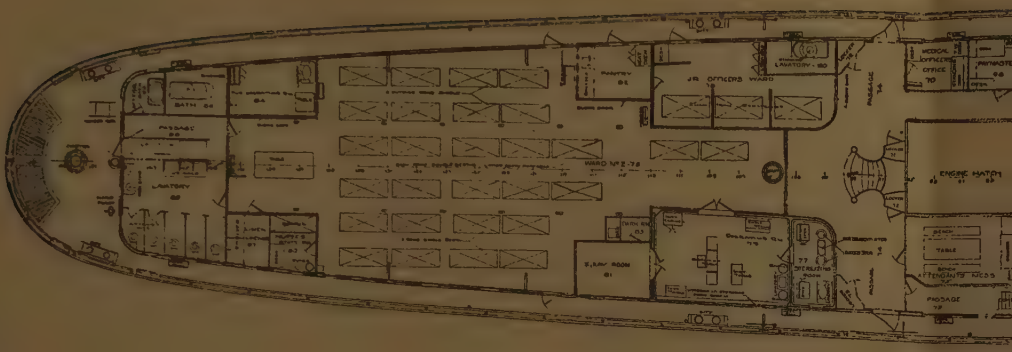
warfare are, to say the least, not favorable for a ship to seek a port, and, failing any relief at sea for a crippled crew, the fighting ship must perforce give up much of her valuable space for hospital purposes, depending on the number of casualties, and thus inevitably impair her offensive and defensive power.[1]

The Model Hospital Ship.—The U. S. S. "Relief," the hospital ship of the United States navy, excellent as it is in many respects, represents an adaptation, and from the aspect of a model is decidedly wanting. "It must be understood that it is no more possible to take any old ship and convert her into a model hospital ship, than it is to take an old house and make a model hospital ashore. As certain constructions

are designed and fitted for distinct purposes, so a hospital ship should be specially designed and built from the beginning with the single idea that it is for hospital purposes and nothing else."[42b] Nor is it possible suddenly to transform a merchant ship in the moment of emergency; but if there are enough trained hospital ships in commission to meet peace demands, the delay in the fitting of others need not be felt, and the expeditious alterations and outfitting of these may be insured by selecting a certain number of ships of the merchant marine and drafting complete plans for their conversion ready for application.[46b] The plans of the U. S. S. "Relief" are given for purposes of study and may be compared with the accompanying proposed plan designed by Surgeon C. F. Stokes of the navy, which is perhaps one of the best. It is to be observed that "in Stokes' plan the engine and firerooms are situated well aft; the idea being to leave free unobstructed space forward and to remove the heat and dirt of engine-rooms as far away as possible."[42b]

A detailed description of the construction and interior arrangements of a type hospital ship is impossible here; but in general the following points present themselves for careful consideration: To be efficient she should be aseptically constructed throughout, with hull of iron or steel, of sufficient size (4000 to 8000 tons) to give stability and high freeboard and to accommodate not less than 200 patients, and should have a speed that will enable her to keep up with the fastest squadron; her accommodations must contemplate sick officers and men (wards with the usual adnexa for cases of a surgical, medical, and infectious or contagious character), officers and crew of the ship, and complete medical staff; her fittings must include dynamos, distilling apparatus, ample ventilating, lighting, and heating facilities, sanitary arrangements (baths, water-closets, dead-room, disinfecting plant, and laundry), ice machines and cold storage, a spacious operating room with adjoining accessories (sterilizing room, *x*-ray room, electro-therapeutic and photographic room, etherizing and recovery rooms), dressing-room, chemical and bacteriologic laboratories, dispensary, dental room, repairing room for instruments, storerooms, specially constructed boats, and convenient means for the expeditious, safe, and comfortable transportation of the sick and injured from or to other ships and to different parts of the hospital ship, which latter should include a light-running elevator, built amidships from the hold to the hurricane deck; her equipment must comprise the complete furnishing and instrumentation of all the above enumerated divisions with a view to treating all manner of cases. In short, the idea in fitting up a hospital ship must be to take the space set aside for hospital purposes and equip, supply, and administer it largely on the basis of a hospital ashore.[42a]

Personnel.—The medical staff will be composed of surgeons for both general and special work, a dental surgeon, a pharmacist, hospital stewards, apprentices (nurses), first and second class, instrument repairer, and specially qualified cooks. The number of these will vary in times of peace and war, but never should the hospital personnel fall below such a running force as will maintain the standard of organization and lend itself to sudden and efficient augmentation.



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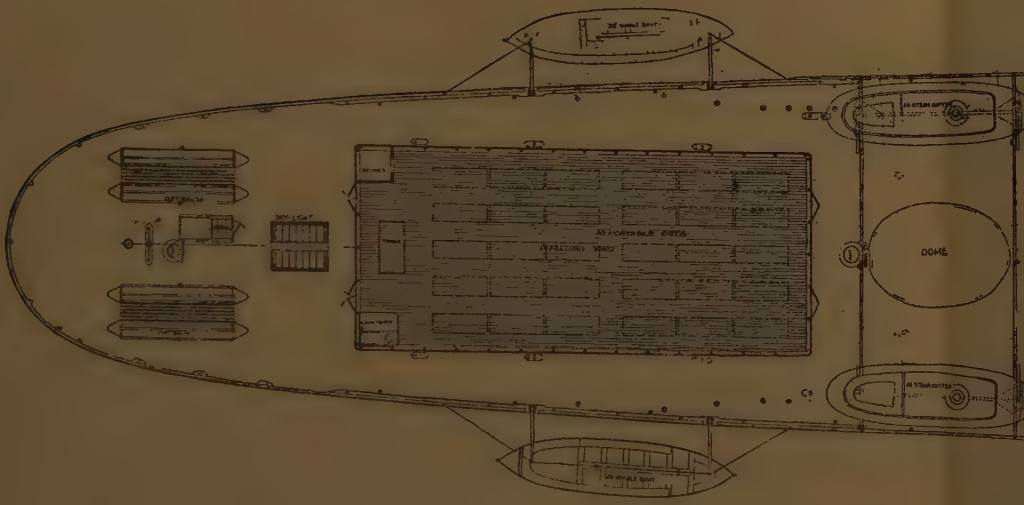

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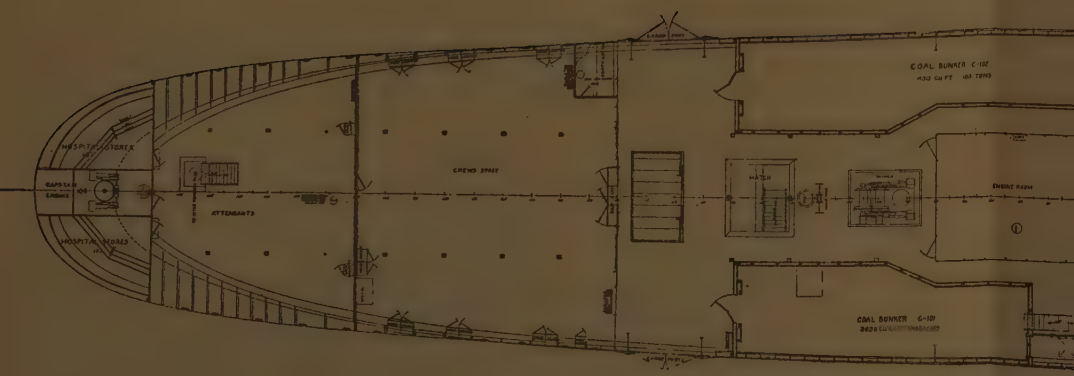

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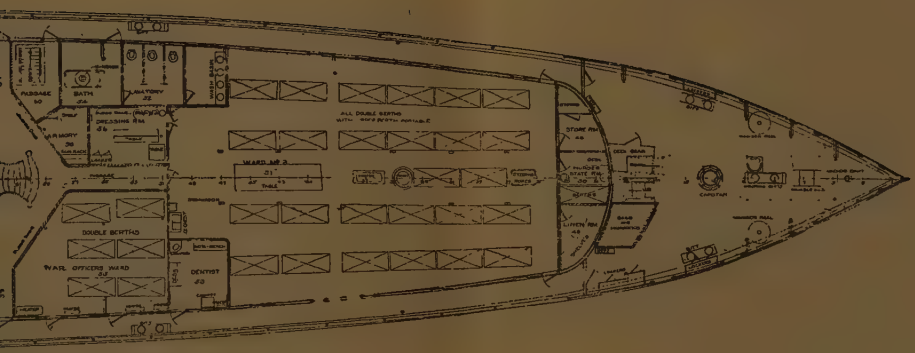
PASSAGE
BATH
LAVATORY
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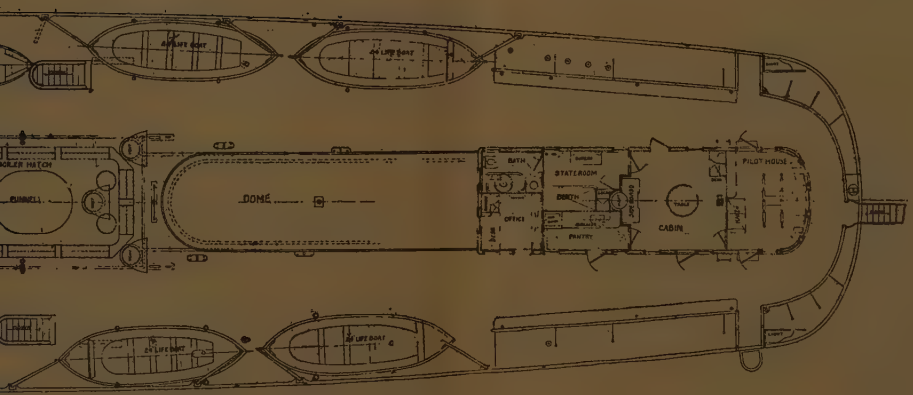
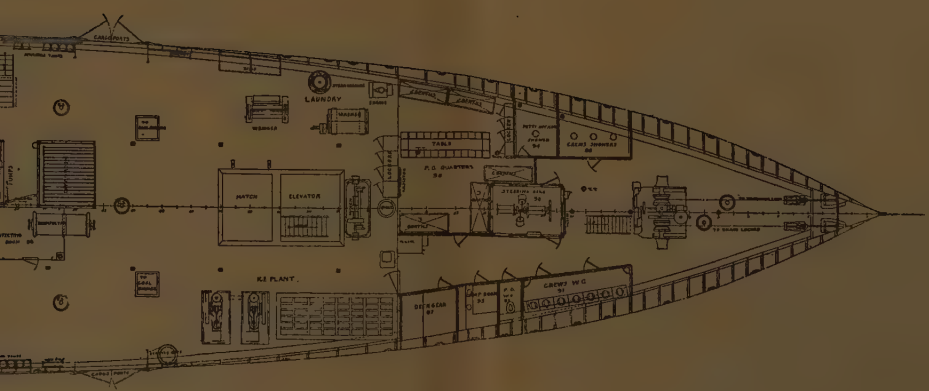
WARD No 3
DOUBLE BERTHS
WAR OFFICERS WARD
DENTIST
STORE RM
CAPSTAN


BOILER HATCH
DOME
BATH
STATEROOM
BERTH
OFFICE
PANTRY
CABIN
PILOT HOUSE


LAUNDRY
TABLE
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ELEVATOR
KE PLANT
CREWS W.C.

The officers and crew concerned in the navigation of the ship must be obtained from the merchant marine, and no officers and men of the combatant force in the naval service should be allowed to serve in these ships.[50b] First, because it would raise the question of conflict with the Hague agreement; second, because naval officers find their greatest need in the fighting line; third, because the use of the international signaling code on hospital ships obviates any need of their presence.[42a]

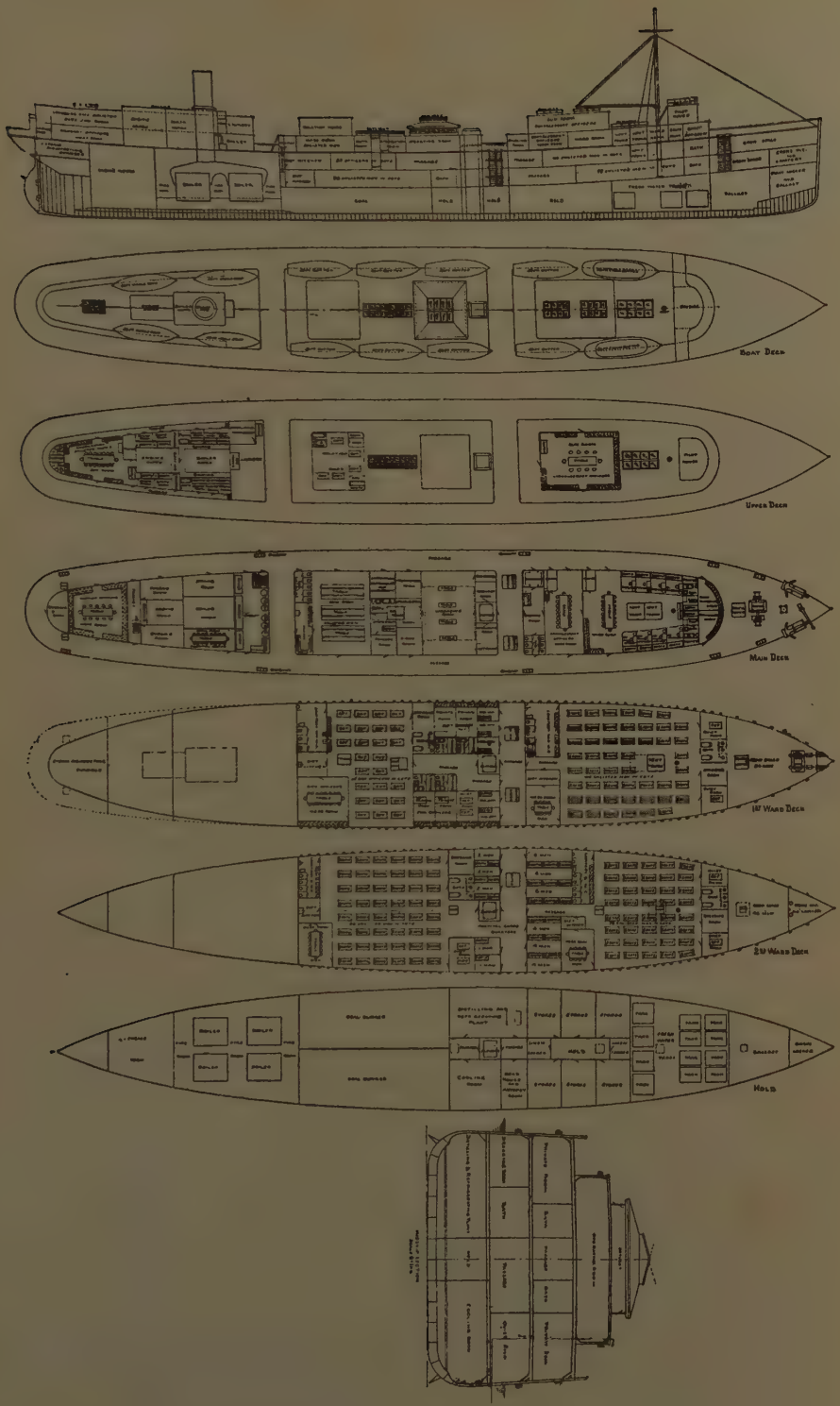
Duties and Working of Hospital Ships.—In Peace.—There is hardly a need to discuss the functions of a hospital ship in time of peace. The advantage accruing from services which they can render must be apparent to all medical men who understand battleship conditions of the present day. Aside from the opportunity which peace offers for becoming acquainted with their interior administration and general duties as a ship, with a view to greatest efficiency in emergencies, there are well-defined service needs which they would fulfil. Their presence in squadron would act to admit the reduction of the space on all fighting ships now necessary for the proper care of the sick and injured; they would represent economy to the government in the transportation of the permanently or indefinitely disabled to base hospitals, the minimizing of permanent invalidism and pension drains through the offer of satisfactory treatment, and the earliest return of those temporarily disabled to their regular stations on the ships of the squadron, with consequent reduction of existing necessarily frequent transfers and maintenance of efficiency by the preservation of those trained to certain duty on the different ships; they would free the squadron commander of an ofttimes inconvenient and, indeed, actually disabling dependence upon base hospitals, by giving him his own floating hospital as an auxiliary to accompany him in all movements and relieve him from more than momentary consideration of the sick in prosecuting his military exercises; they would serve to relieve all anxiety concerning a ship's crew upon the development of a contagious or infectious disease, and would thus secure the integrity of the fleet; they would serve as supply depots from which to replenish surgical supplies on the battleships; in short, they would furnish a means by which independently to maintain the personnel of the squadron in a state of highest physical condition, and further, they would offer asylum to the seriously sick or otherwise disabled and militarily useless members of the crew up to the last moment before battle, thus clearing the spaces required for the accommodation of those injured in battle, and leaving the ship's medical staff free to devote all their energies to those wounded in action.[46b]

In War.—This subject opens up a broad field for discussion, touching upon their safety, the question of possible interference with the combating ships, and the requirements of international law. The part that the hospital ships should take and their positions have not been definitely established,[50b] but there are a few recognized obligations and rules of conduct, independent of all mooted points, which help to determine their movements. First, they must not be the cause of hindering or prolonging battle, which up to the decisive moment is the only question of importance

at the time. Second, no commanding officer can guarantee or even consider the safety of the hospital ships during the maneuvers of his ship or fleet, and they must keep outside the danger zone. Third, the hauling down of the flag must be regarded as the only signal which hospital ships can respond to, as until then the adversary can permit no interference by neutrals.[27] Nevertheless, during an engagement, whether of a running nature or of opposing squadrons circling round each other, the hospital ship with superior speed as a *sine qua non*[50b] must follow and keep as constantly in touch with the belligerent ships as the attending conditions will permit, and be prepared to respond to orders from the admiral or to go rapidly to the assistance of a sinking, burning, or otherwise disabled ship which has been left isolated or has retreated beyond the line of fire.

After Battle.—However surrounded by a haze of uncertainty the conduct of a hospital ship during battle may be, there can be no doubt or hesitancy as to her duty at the conclusion of battle. Then the principles of humanity immediately prevail—then the governing conditions are of a less variable, trying, and complex nature—then the unquestioned moment for intervention has come and the work of rescue must be pursued with system and celerity. It is presumed that the hospital ships of the victorious side would go to their own men-of-war first, and the enemy's ships after that in rotation, according to the needs of the particular ship, though any ship so damaged as to be in imminent danger of sinking, regardless of side, in the concluded hostilities, would naturally and properly claim the first benefactions of the hospital ship. And now, having collected the wounded to the limit of their capacities, the indication is clear that while continuing the work of fullest relief to the injured they must make "all speed to the nearest shore hospital, and having landed their cases, rejoin their squadrons without loss of time."[46b]

Transportation.—The debarkation of the wounded requires special provisions by various devices, according to the stage of the process of transportation. But though small boats constructed with particular reference to cot and litter transportation must be included among the provisions, there should also be some method for rapidly, safely, and comfortably transferring the patients without them. Perhaps the most elaborate and elegant yet seemingly feasible method is that contemplated in the "Stokes apparatus for transferring the wounded at sea," which proposes to effect the transportation by means of a wire rope hawser, guiding lines, an adjustable sheave, an electric winch, a weight for taking up slack, and a transferring car, the splint stretcher supported by a wheeled rod serving admirably as a transferring car. This apparatus is to be operated after the manner of all similar overhead trolley carriages, and the connection with the ship to be assisted is accomplished by means of the coast life-saver's rocket. The component parts of this simple apparatus are to be had out of the usual equipment of every sea-going ship, so that it may be improvised if need be; but should experience prove the method to be practicable, the necessary gear for this specific purpose should be assembled complete at a fixed place on every hospital ship ready for immediate use by a crew drilled to its intelligent manipulation.



Composite Plan of Ideal Hospital Ship.

Other methods will have to be employed and preparation for the occasion when they may be needed must be made. For receiving and transferring patients over the sides of the ship,[42a] davits and cranes and outboard hatches and cargo ports are required. The slightly wounded and those able to walk may use the gangway and thus effect their own transfer. Stretcher cases can be carried directly through the cargo ports, by the use of a little staging, or suspended horizontally or vertically on pulley and tackle from a small crane and lowered to the boats or lighters, or hoisted to the deck, with ease and safety. Or, again, large platforms[16] sufficient in size to hold two or more stretchers, and with a guard-rail, may be suspended by ropes and swung clear of the ship's side and lowered, or hoisted and swung inboard sufficiently to deliver the patients fairly on deck. When necessary, small winches could be used to work the cranes. In some instances it will be convenient for the bearers to carry stretcher-borne patients up or down the gangways.

Surgical Program.—As soon as the first cases have been transferred to the hospital ship the work of thorough relief and more careful dressing, where first aid only has been rendered, should be instituted by those of the medical staff free to engage in operation, and from that moment and until the destined port of discharge has been reached this relief must be unfalteringly carried on. Wounds must be properly examined, diagnoses made, and all indications met with a strict observance of the rules of asepsis or antisepsis. Search for shell fragments, foreign bodies, and fractures, must be made early and the *x*-ray employed as common routine.[25] In the performance of this important work system is absolutely necessary, as it conduces to thoroughness and expedition, which in turn mean justice to the patient and economy of time. The examination, description of case, completion of record (including drawings, photographs, and radiographs), the preparation of the field of operation, the anesthetizing, the operation, the dressing—all must be carried on with that quiet despatch and methodic regularity which so eloquently attest efficient administration and professional ability, and are so capable of accomplishing large tasks.

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CHAPTER LXVIII.

TROPICAL SURGERY.

By Walter D. McCaw, M.D.,

UNITED STATES ARMY.

GENERAL CONDITIONS AFFECTING SURGERY IN THE TROPICS.

It is essential that the surgeon undertaking to practise his profession in any hot country should study the effect of climate and environment upon his clientèle, especially the differences existing in this respect between the dark-skinned natives of the place and the colonists or sojourners of European blood. He must understand and be able to recognize symptoms of many pathologic conditions which are seldom or never seen in temperate regions, but which in the tropics may vitally affect surgical diagnosis or the results of operative procedure. He must also have a practical knowledge of whatever difficulties exist in obtaining the excellent material and the same efficient assistance considered so necessary in well-conducted surgical operations at home. These are points of fundamental interest in his practice as a general surgeon, beyond which he must, of course, be governed by the same principles of surgical diagnosis and treatment as elsewhere in the world, for there is little, if any, special surgery of the tropics.

"Tropical diseases" have come to mean, in general usage, not only the few maladies which exist in the torrid zones, and there alone, but also the diseases which from any cause are found most often in hot regions, and are seldom seen in the civilized countries of the temperate zones. This last class is a very large one and includes many of the great infectious diseases which have prevailed in the past in all climates, and even now appear occasionally in epidemic form far from their permanent homes. Thus, cholera and bubonic plague have come to be considered "tropical diseases," as the best conditions for the maintenance of endemic centers exist in the torrid zones or in the neighboring subtropical regions.

Leprosy also, with the exception of a few limited districts, now prevails only in warm countries, where its continued existence probably depends on racial and social factors, rather than upon climate or meteorologic conditions. Malarial fevers, certain forms of dysentery, diarrheal complaints, and many common parasitic diseases assume much greater importance in the eyes of the practitioner in the tropics than elsewhere.

The diseases that are entirely non-existent outside of the tropics are quite limited in number, and of these very few have any distinct surgical interest.

The Influence of Climate.—The effect of tropical climate upon the physical and mental condition of white colonists has been the subject of much study by competent observers belonging to the various great colonizing nations of the world. It is fully recognized that the greatest price paid for colonial power has been the enormous loss of life and health attending the establishment of settlements in hot countries, especially when, as is generally the case, military operations are undertaken. For a long time this mortality and chronic invalidism were credited to climate alone, but in the light of our modern knowledge of disease causation and disease prevention, much of the apprehension attending tropical life has disappeared, as it is now known that the white man's life and health are infinitely more endangered through infectious diseases transmitted directly or indirectly from man to man than through meteorologic conditions. This is an encouraging fact, as self-protection against infection is always in a measure possible, but against a permanently high temperature and an atmosphere reeking with eternal moisture little defense can be offered.

There are wide variations of climate within the rather indefinite limits of that part of the earth's surface we call "tropical." Regions where the annual mean temperature is 65° or above, at sea-level, are, roughly speaking, those where tropical vegetation and animal life are found, where the original inhabitants are dark-skinned, and where tropical diseases flourish. The isothermal lines are not identical with parallels of latitude, but curve irregularly from or toward the earth's equator.

The characteristics of tropical climate which make it inimical to the health of white men are primarily two in number: the high temperature of the air and its great humidity. Where there is but slight seasonal change and these two conditions are present all the year round, the climate is almost unbearable to those of European blood.

On the equator, and for 10 or 12 degrees north or south, there are four seasons, but no marked differences between them. There is a mean temperature of about 80° and constant humidity with excessive rainfall. The equal length of day and night, and the constant humidity, which interferes with radiation, prevent those differences in sea and land temperatures which are necessary to produce the inland breezes, so that hot damp days are followed by hot damp nights throughout the entire year.

Outside of the equatorial belt there are tropical and subtropical regions characterized by two distinct seasons: a long hot summer, including a well-marked rainy season, and a short dry winter, when the weather is delightful. As the subtropical belts, north and south, begin to merge into temperate regions, areas of great aridity are found in both hemispheres, and in these desert lands the heat is usually intense by day, while the nights are by contrast very cold. The greater the distance from the equator, the greater is the range of temperature for warm climates; and thus the maximum temperature of subtropical or even temperate lands may greatly exceed the maximum on the equator, although, owing to the greater range, the mean temperature is much lower.

The eternal heat on the equator or the relatively long summers in

subtropical countries affect adversely the health of members of the white race on account of the *duration* of the hot weather, rather than the intensity of heat, but, after all, the moist heavy atmosphere is by far the most dangerous as it is the most unpleasant climatic feature. It is at sea-level that heat and humidity are most constant, and therefore cause most suffering. Elevated regions, even in the equatorial belt, may have climates both delightful and wholesome for Europeans. The great plateau of Mexico is an ideal summer climate well within the tropics. During the rainy season showers occur daily in the afternoon only, while the mornings are sunny and mildly warm. The summer residences of European governors in India and in Java are healthful refuges for the white women, children, and invalids from the lowlands, and Americans in the Philippine Islands thrive in the highlands of Benguet or the mountain stations of Mindanao.

Arid countries are, generally speaking, healthful for the white race, for both heat and cold are well borne in the dry air of a desert when care is taken to guard against the sudden alternations of day and night temperatures. At sea-level the littoral climate is generally better than at places inland because of the sea breezes at night. Small islands are also cooler in hot seasons than the neighboring mainland. White residents of the tropics bear high temperature well wherever there is respite through cool nights or fairly bracing winters, but they are bound to suffer in health when heat and humidity are constant.

When the air exceeds or even approaches the normal blood heat of 98.4° F., and contains watery vapor not far from the point of saturation, thus checking surface evaporation, it takes but little to produce a febrile condition. Slight exertion or even the ingestion of food and drink are followed by profuse perspiration which does not evaporate and cool the body as it should. Food material which ought to be oxidized for the production of body-heat is not needed and must be merely excreted, with the result that the eliminating organs of the body, the liver and kidneys, are overworked. The pulse loses force and frequency and the arterial tension is lowered as a result of excessive perspiration. Respiratory action is decreased, for while there is indeed an increase in lung capacity noticed in newcomers to the tropics, it is not permanent, and heated air being deficient in oxygen, the system of the white man does not receive the oxygen it is used to and needs. The bodily nutrition therefore suffers, both red cells and hemoglobin being considerably reduced, with a resulting anemia. In spite of the enormously increased amount of water ingested by most white people in the tropics, the amount of urine excreted is relatively small. The skin eliminates water to such an extent that it is an ordinary occurrence for a soldier on the march in the tropics to find his urine nearly suppressed, and to pass with considerable difficulty a few drops only of scalding and high-colored urine until rest and plenty of water restore normal conditions. Some individuals indeed, with chronic kidney troubles, find tropical life distinctly beneficial to their crippled organs on account of this vicarious action of the skin.

The digestive fluids of the body also suffer a decrease, with the result

that disturbances of digestion, such as flatulence, gastric distress, constipation, or slight diarrhea, are to be constantly expected, the sufferers by no means regarding themselves as invalids, but taking their tonics and liver pills as a matter of course. The liver is nearly always overstimulated in Europeans, with their habits of too liberal eating and drinking, and this leads, as will be demonstrated later, to serious diseases, while torpid liver is common to all. The excessive perspiration during the hot weather is accompanied by prickly heat or other annoying skin lesions which really cause much suffering, as sleep is disturbed, and the well-known nervous irritability of white men in the tropics is often due to this. The immediate environment in tropical countries is, however, after all, of much greater moment to the health of the white race than any variations of heat or moisture. The local sanitary conditions as to drainage, disposal of filth, density of native population, purity of the water for drinking, sufficiency of suitable food, and, above all, liability to special infections are, on the equator as elsewhere in the world, the main factors in the public health.

It may be accepted without question that the dark-skinned natives of hot countries are not injured by purely climatic conditions and that the hot, moist air so trying to Europeans is for them entirely suitable. With the white residents it is different; they may be, it is true, acclimated to such an extent that they are apparently unaffected by the climate, having reached a certain standard of health which may be considered normal, although they do not eat or sleep quite as well as at home and are unable to work or think with the same vigor and sense of enjoyment. Others are subject to certain common complaints, nervous, intestinal, etc., which really make them semi-invalids, though not allowed to keep them from their work. A very few, without nerves and of iron mold, will retain their vigor of body and mind apparently regardless of temperature or season.

Food and Habits of Natives and Europeans.—The old white settler in the tropics, he who has best become acclimated, profits by his knowledge of native customs pertaining to eating and drinking, clothing and housing. He has the immense advantage over the native in that he knows or is able to understand the reasons for customs in diet and daily life which have been acquired by the native people by the experience of centuries, but for which they could give no valid reason. He is thus able to adopt what is best and improve upon it. The staple food of a people is sure to be the best and most nutritious available, although the native manner of preparing it may not appeal to the esthetic sense or to the palate of the white foreigner. We generally find that the white men in the tropics have adopted many of the dietary articles, and that they are wise in so doing. At the same time it does not follow that the native dietary is an ideal one even for themselves, much less is it apt to be suitable in its entirety for those of European blood, with their inherited appetites. The absence of many articles of food to which the white settlers are accustomed at home is a fertile source of ill health to the newcomers. But to carry on the European or American habit of

eating three heavy meals a day, with an excess of nitrogenous food, and more particularly to indulge in alcoholic stimulants to the extent customary in temperate climates, are still more surely followed by disaster. With the natives of hot countries over-indulgence in the pleasures of the table is rare; on the contrary, poverty is often the cause of such enforced frugality that the population as a whole is underfed and sickly. In investigating the general health of the clientèle upon which he is to practise, the practitioner in the tropics soon finds out that both natives and white men have certain advantages and disadvantages as subjects for surgical treatment.

The Europeans are apt to be below par in health, to be more or less nervous and irritable. They are, however, usually living under better hygienic conditions than the natives because they themselves, or the health authorities thinking for them, understand the reasons therefor, and are in sufficiently good circumstances to obtain the best food and comforts. Most important of all, the white man seeks professional advice as soon as possible, as his health is ever present in his thoughts. He is not as obedient a patient as the native, but is more reasonable, and is free from superstitious, religious, and caste prejudices which are the despair of physicians practicing upon Orientals.

The natives of moderate circumstances are in normal health, unaffected by the climate, and without nervous irritability. They bear pain stolidly and are obedient in an uncomprehending way. From sheer ignorance, however, or from some iron-clad rule of religion, custom, or caste, the best work of the surgeon may be brought to naught. Operative measures, especially when the slightest mutilation is necessary, are much dreaded, and generally postponed until the last moment, so that in the long run a more serious class of cases is furnished from the native population. The poorer classes are also apt to be in a very underfed condition and have but slight powers of resistance. This is especially the case with children, who have but little stamina.

Shock.—The likelihood of surgical shock in white and dark-skinned patients is an important point for consideration. Reasoning *a priori*, it would seem inevitable that the shock of a severe injury or of a capital operation would result fatally more often to white men in the tropics than at home, but as a matter of fact there is no such great difference. Allowing slightly for the less robust health of the white men, and their tendency to nervous irritability, the results of capital operations in hospitals and under equally good technic compare favorably with like operations in the United States. The tendency to shock in native patients differs very much in the various races and lands. While the inhabitants of lower India, for example, are said to bear surgical operations badly, the reverse is true of Malays, Mongols, and negroes, who resist shock very well. In rapidity and completeness of convalescence the natives of a country have a great advantage. Foreigners, although they may resist the effects of a hot climate from their initial vigor, and by using their intelligence, can seldom make up any serious loss of vitality while remaining there. The question of sending home a white patient for operation often comes up

for decision, and unless time be not an important element in the case, it will generally be found, all things considered, that the best interests of the patient require operation on the spot, but with a long period for recuperation in his native land. The supposed greater danger of a surgical operation in the tropics over the same procedure at home is seldom an important enough consideration to overcome the advantages of prompt action.

Wound Infection.—The evil results of wound infection are neither more nor less to be feared in tropical lands than elsewhere. A really competent surgeon may rely upon his aseptic technic just as confidently in Manila or Calcutta as in London or Philadelphia. Not only is this the case, but in accidents and in military surgery, where contamination is often inevitable, proper cleansing and dressing are followed by perfectly good results as often as in temperate regions. If the heat and moisture of the tropics are favorable to bacterial growth, yet the blazing sun of the dry season is a powerful germ destroyer, and, as a matter of fact, septic and pyemic conditions are not particularly common. I remember, it is true, some serious cases of rapid sepsis following trifling injuries, but nearly always in subjects enfeebled by long residence or suffering from some chronic complaint. Wounds contaminated with the soil of the filthy villages in the Philippine Islands are rather liable to infection by the fatal B. aërogenes capsulatus, and the possibility of this must therefore be especially kept in mind there, and probably in other hot countries. Many places in the tropics, but by no means all, are also hot-beds of tetanus. It was predicted by Cubans, before the invasion of the island by our troops, that our wounded would run great danger of tetanus, but the prophecy fortunately failed in the campaign of Santiago de Cuba, where the slightly wounded nearly always recovered under the first-aid dressings without sign of infection of any kind.

The difficulties of surgical practice in the tropics in many directions may be great compared with the facilities of European and American cities, but at least there is no *climatic* reason for failure of the recognized proper procedure in competent hands to produce equally good results.

Before taking up the diseases of the tropics that are of especial surgical interest it is in order to remark briefly upon some of the morbid conditions which are so common that their presence or absence must be made a factor in the diagnosis in every patient who seeks treatment.

Anemia.—Compared with the full-blooded inhabitants of northern Europe and America, the natives of hot countries are all more or less anemic. This condition, normal with them, is acquired by white settlers in the process of acclimation. Whenever, however, the anemia is profound, the cause must be looked for in the presence of some chronic infection or parasitic disease. A very common cause is the presence of some of the numerous intestinal parasites which are especially fostered in the tropics by climatic conditions and the racial habits and customs.

The common roundworm, which in the United States is mostly seen in children, is practically universal in the tropics. Certain tapeworms are common enough, especially the Hymenolepis nana, or dwarf tapeworm,

which our soldiers are bringing back to America in scores of cases. The presence of either of these parasites may be associated with considerable anemia, and also with various disturbances of the digestive organs, the dwarf tapeworm, indeed, often causing serious choleraic diarrhea. An intestinal worm particularly to be looked for in anemic patients is the Anchylostomum or hookworm and its new-world relative Necator. Following the discovery of the Necator americanus by Stiles, came the announcement of Ashford, in Porto Rico, that the deadly "anemia" of the island was really anchylostomiasis. This, and the numerous reports of physicians in the southern States, brings home to the medical profession of the United States the great importance of taking this parasite into consideration as a possible factor in every case of so-called "anemia," "malarial cachexia," "general debility," etc., coming up for diagnosis in a warm country. Intestinal parasites may for a long time give rise to only slight symptoms in their host, yet when he is weakened by injury or disease their presence seriously complicates the prognosis: so the practical lesson for surgeons is the necessity of making an examination of the stools of every patient before surgical operations are undertaken. The process is so simple, and the technical knowledge required so slight, that there is no good excuse for omitting this important procedure in any case.

As for treatment, in thymol we have, fortunately, a very effective means of getting rid of hookworms; the dwarf tapeworm is expelled by male-fern or any other well-known teniafuge; and santonin is, of course, indicated in the numerous cases where eggs of the Ascaris are found in the stools. Besides worms, several families of Protozoa are parasitic in the human intestines, but a consideration of these will be taken up under the head of tropical dysentery. Occasionally the examination of a patient's dejecta will disclose an amazing collection of intestinal inhabitants. I have in mind a friend in Manila—an officer of the army—who possessed within himself, and carried around without signs of ill health other than moderate anemia, a menagerie consisting of three varieties of the worm family and two Protozoa: namely, Ascaris, Anchylostomum duodenale, Trichuris trichiura, Cercomonas intestinalis, and Amœba coli.

The pathologic conditions and the infections which cause anemia in cold countries are not to be ignored in the tropics, but the preponderating influence of *animal* parasites as a cause of ill health must always be borne in mind.

Malaria.—It is hardly too much to say that in malarious regions every inhabitant is more or less infected. The natives of such countries, usually as children, have experienced repeated attacks and have attained a sort of immunity, really a toleration, for the parasites can very often be found in their blood and an occasional outburst is not uncommon. Malaria also is a great factor in the death-rate of both children and adults of the native population, either directly or indirectly, but such as have reached adult age are not often subject to very severe attacks, and consequently they live for years in localities deadly to Europeans without apparently bad effect. Certain of the white residents of the tropics are, or soon become,

quite resistant to the infection, and after an attack or two consider themselves "acclimated" or "immune" to malaria. In nine out of ten cases, however, they harbor the parasites, which are only kept from manifesting their presence by paroxysms of chill and fever, on account of the natural resistance of the host backed up by his habit (universal among white dwellers in the tropics) of taking quinin whenever he feels a little unwell. Most white residents who have acquired the malignant malaria of the tropics are well aware that complete recovery is not to be expected without a prolonged absence in a cold country, and they therefore fight the disease off as well as they can with drugs and comfortable living, accepting an occasional exacerbation as a matter of course. It is well understood that, even among the healthiest, anything which lowers vitality, such as exposure, injury, overwork, or even great mental depression, is apt to provoke a malarial paroxysm. Such a widely distributed disease is therefore of great importance to the practising surgeon as affecting both his diagnosis of many supposedly surgical conditions and the prognosis of his operative cases.

A carefully taken history of every patient, blood examinations, and search for the evidences of malarial cachexia are necessary before undertaking operation, and where time permits a course of treatment with quinin, tonics, and arsenic will often be indicated. When malarial fever occurs after operation, it is sometimes of very severe type and threatens life directly. More often convalescence is retarded and repair interfered with; indeed, gangrene has been attributed to malarial cachexia. Even when the case terminates favorably the occurrence of chill and fever after a surgical operation is a cause of much anxiety to the surgeon, well worth avoiding at the cost of a little trouble at the beginning.

Opium Habit.—The habitual use of opium by smoking or swallowing is not a matter of very great importance to tropical surgery. The habit is widely spread among East Indians and Chinese, but is not common among negroes and Malays. The majority of its devotees are by no means physical wrecks nor mental perverts. There are opium drunkards among Orientals just as there are alcoholics among our people, but most members of the dark-skinned races can use the drug for its pleasant effects in moderation, much as we use tobacco, so that although the vice of opium-taking does undoubtedly seriously affect for harm the energy and usefulness of the races addicted to it, it does not follow that every user is to be considered a subject for medical treatment on that account alone. Surgery can be undertaken upon opium habitués without fear of any special untoward results, but it would be dangerous to withdraw the drug after operation, and as to the amount to be allowed, the wisest plan is to permit the patient or some intimate friend to furnish it in such quantity and of such quality as they see fit. A white physician attempting to prescribe opiates to a suffering Chinaman, and depending upon his knowledge of American materia medica, is apt to find himself in a quandary. I remember a ghastly bolo wound of the neck in a Chinese coolie boy in Luzon, where the patient struggled fiercely against an anesthetic, but on being allowed to swallow two enormous boluses of opium furnished

by a sympathetic friend of his own nationality, underwent the tedious cleansing and closing of the wound without a murmur. During his convalescence he kept a box of the pills by his cot and partook of them at will.

Beri-beri.—This mysterious specific multiple neuritis is common among natives of many warm countries, but very rare in white residents. The disease presents many analogies to post-diphtheritic neuritis, and indeed it is more than probable that the real disease is a duodenal infection by some germ producing a powerful toxin, and that the long train of symptoms called beri-beri are those of a toxic neuritis existing after the initial trouble has disappeared. Involving as it does the nerve terminals in the heart as well as elsewhere, the most serious symptoms of the disease are cardiac dilatation, myocardial degeneration, serous effusion into the pericardium, etc. One never knows just how seriously the heart is affected, but if that organ holds out recovery is assured, even if the symptoms have been alarming. On the other hand, a patient with few symptoms, and those not serious, whose convalescence seems certain frequently dies of a totally unexpected heart failure. The invariable rule should therefore be to subject no beri-beric to anesthesia or to any sort of surgical operation, where there is any choice in the matter, and this regardless of an apparently good physical condition. Venesection for the relief of a laboring heart in acute dilatation or aspiration of pleural or pericardial effusions may indeed be required in the treatment of the disease.

Syphilis and Chancroid.—In tropical seaports syphilis is rife, and, as elsewhere, is a great factor in diagnosis and treatment. There is great variation in the severity of the disease in different places, but although much has been written about its course in patients of the various races, climate at least seems to have no special bearing in the premises. In the interior, among people remote from the ordinary trade routes, the disease sometimes does not exist at all, and tribes hostile to the whites or holding themselves aloof from them on account of religious or caste feeling sometimes escape, for there is no denying that the most gentle and friendly of the colored peoples coming under the rule of our race have been the worst sufferers. Chancroid is excessively common and is the cause of many admissions to the sick report among our soldiers in the Philippines. A noticeable feature is the frequency of suppurating bubo in these cases; in numerous instances the initial sore will have entirely healed without leaving a trace, and yet a week or so later the bubo will appear. This undoubted fact has made it difficult for army surgeons to recognize the existence of such a clinical entity as "tropical bubo," although the term is often seen.

Tuberculosis.—This is rare in some parts of the tropics and very common in others. It affects all races and is invariably found in the crowded native quarter of large cities. White persons acquiring tuberculosis in the tropics should return to a colder climate, for where it is difficult at best to keep oneself in good physical condition, it is impossible to resist effectively any chronic disease. Army patients are always

sent without delay from Manila to the Government's sanatorium in New Mexico. Lupus, and surgical tuberculosis generally, have so seldom been reported from hot countries that they must be quite rare. Statistics of morbidity, however, are exceedingly incomplete for the colored races, outside of the United States, and we know but little as yet concerning the prevalence of some of the cosmopolitan diseases in the tropics.

Diabetes.—The native inhabitants of India and Ceylon are said to suffer from diabetes to an unusual extent, and it also frequently occurs among the Anglo-Indians. It has not, however, been observed as a specially common complaint in any of the tropical possessions of the United States.

Tumors.—Cancer is a rare disease in the tropics; indeed, it is practically never seen in some countries. The Mongolian race (the Chinese especially) is, however, an exception, and is very prone to tumors of all kinds, malignant as well as benign. The frequency of *keloid* among the black and yellow races is very noticeable.

Operative Surgery in the Tropics.—While the results of surgical operations are, taking all things into consideration, about as good in tropical hospitals of the best class as at home, the practitioner at remote places without a well-organized institution to which he can take his major operations must shoulder responsibilities of which surgeons of our large cities are relieved. Generally no consultant of equal or greater skill than himself is at hand to share the burden, often no trained nurse is within a thousand miles, and the operator must attend to preparation of the patient, the arrangement and the sterilization of the material, and the after-treatment. The lack of trained assistance calls for much self-reliance and makes an operation of any importance a considerable tax on mind and body. Native-born assistants of the more intelligent races can be trained to an automatic obedience in carrying out the instructions of the surgeon, but can rarely be trusted to do any thinking for themselves.

Anesthetics.—Chloroform is considered by the English surgeons as particularly adapted for tropical use, as the operations are practically carried out in the open air or under a punkah, and the danger of too great concentration of the anesthetic is reduced to a minimum. The Americans in Manila use both chloroform and ether as they wish, but the latter drug is wasteful in very hot weather; it seems to evaporate more quickly, and sometimes the patient takes enormous quantities without the desired result.

Instruments.—All metal instruments should be of the best quality and as simple in construction as possible. The eternal moisture of the tropics quickly ruins steel instruments unless they are daily cared for as a soldier cares for his rifle. No container short of a soldered tin can be trusted to keep out moisture, and in shipping instruments to the tropics they should be dried at a high temperature and inclosed in soldered cases. It is much better to keep the whole armamentarium in use exposed on the shelves of a glass surgical closet than to put the instruments away in cases. An intelligent Chinese or Malay servant should give them

daily attention by rubbing with chamois skin and a very little cacao-butter or vaselin. Hypodermic syringes should be all metal, and the needles of gold or other non-corrosive metal. The needle for spinal anesthesia should by all means be made of gold, as there is always danger of breaking it when the puncture is made. All the surgical needles now sent to our army in the Philippines for field use are gold-plated, and this has been found to be an economy as well as a convenience. Rubber tubing and catheters are very short-lived; they should be kept in their original sealed packages until wanted, those for daily use being kept immersed in a carbolic solution. No drainage-tube or catheter should ever be used without carefully testing its integrity, as very often an apparently sound bit of rubber will break into fragments when stretched in the slightest degree. The aspirator and Paquelin cautery will generally be found in a chronic state of uselessness from the rapid deterioration of the tubing.

Time of Operation.—The most pleasant time of the day is the early morning, and both in the interest of the patient and for the comfort of the surgeon and nurses it should be selected for the operation whenever possible.

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7. Military Surgeon (The), Carlisle, Pa. (monthly).

Surgical Diseases of the Tropics.

LEPROSY.

Leprosy is a chronic infectious disease, characterized by the growth of granulation tissue in the skin, mucous membranes, peripheral nerves, and less often in other situations. The specific cause is the Bacillus lepræ, discovered by G. Armauer Hansen.[1] The history of leprosy demonstrates that it has prevailed in both hot and cold countries, but there is good reason nevertheless for treating of it among tropical diseases, because at the present time it prevails to a far greater extent in tropical and subtropical regions than elsewhere, and owing to social and racial factors it will probably continue to do so. There is also evidence for believing that the disease originated in a warm climate, for leprosy is of

very ancient record, and was recognized, long before the Christian era, as the most terrible of maladies in Egypt, in Palestine, and in India. Its wide European distribution in ancient times and in the Middle Ages has been with good reason attributed to importation from Asia and Africa by the returning soldiers of Pompey and other Roman generals and by the Crusaders. At the present time leprosy exists outside of the warmer regions of the earth only in small and widely scattered centers of disease, as far north as Iceland and eastern Siberia, and as far south as New Zealand. It is found in both North and South America, and in all probability was introduced into the southern continent from the old world by negroes and sailors. In the United States Chinese immigrants brought it to California, Scandinavians to Minnesota and the northwest, in which region, however, the disease is fortunately disappearing. The largest and oldest leprosy center in the United States is in Louisiana, where it has existed for over a century, and the majority of these patients are American-born. Altogether, there are now several hundred lepers in the United States.

The acquisition of Hawaii, the Philippine Islands, and the Panama Canal zone has brought a very large leper population under American jurisdiction, so that this ancient malady, which was scarcely mentioned in the American text-books of twenty-five years ago, has become a matter of general interest to the medical profession of the country, and of special importance to those settling in the new colonial possessions.

The specific cause of the disease, the B. lepræ, is found in all forms of leprosy, and in well-advanced cases the bacilli are widely distributed in the body, existing in enormous numbers. The microbe closely resembles the B. tuberculosis in appearance and also in staining reactions. It is a slender, straight rod with rounded ends, perhaps a little shorter than the B. tuberculosis. Under the microscope the bacilli are seen in heaps and bundles rather than singly, and always in great numbers. The bacillus does not form spores, but spaces that do not take the stain are often seen, a fact that has led to a description of spore formation in the organism by some observers. The identity of the micro-organism of leprosy and tuberculosis has often been advanced, and, indeed, differentiation by appearance and staining qualities alone is well-nigh impossible. The widest differences are shown when attempts are made to cultivate the B. lepræ either on laboratory media or by inoculation, for it is more than doubtful whether the organism has ever been made to grow artificially. Many bacterial growths, it is true, have been obtained from material taken from leprous nodules, but none have been generally accepted by bacteriologists as genuine cultures of the B. lepræ. Very recently Emile-Weil[2] has reported successful cultures of the Hansen bacillus upon media containing pleuritic serum or those to which yolk of egg had been added. A viable germ could only be obtained from a leprous nodule of recent appearance, those from older lepromas not growing at all. The nodule was carefully sterilized and opened with a scalpel, and a minute cylinder of tissue, free from blood, containing some cellular elements and bacilli in pure culture, was obtained with a pipet. This

when planted upon the media gave rise, in a few instances only, to very frail colonies. The growth soon died out, apparently when the cells transferred from the leproma had disappeared. By carefully inserting the contents of the pipet through the shell and into the yolk of a fresh egg cultures were also obtained which not only developed while the imported leproma cells lasted, but thrived for a while upon the cells of the egg yolk. Germs from the old nodules and other cutaneous lesions, as well as those from the nasal mucus, could not be made to grow, and on no other media than those described above was any evidence of life shown.

Inoculation experiments, upon man and animals alike, have nearly always proved failures. In 1884 Arning[3] inoculated an apparently healthy Hawaian under sentence of death by stitching a piece of fresh leprous tubercle into a deep incision in the skin. Painful swelling of the ulnar and median nerves took place in the inoculated arm in four weeks, and later a nodule appeared at the site of inoculation. Three years afterward true tubercular leprosy was fully developed, causing death six years from the date of the experiment. The subject was, however, of a leprous family, and had lived among lepers in a country where the disease is wide-spread, so that this single case is not at all conclusive.

Many similar attempts made in Norway and elsewhere have always resulted in failure, and inoculation experiments on animals have also yielded almost entirely negative results. Exceptionally a local neoplasm resembling leprosy has been obtained. In 1905 Nicolle[4] reported a successful inoculation of a monkey, with the production of a nodule on the sixty-second day. The nodule was excised on the seventy-fifth day and showed the characteristic masses of bacilli in great number.

Judging from the almost universal failure of experimental inoculation it seems probable that the organisms found in skin lesions as well as in those thrown off from the nasal mucous membrane are nearly always dead. The problem of how living germs of leprosy capable of infecting new subjects are actually transmitted from sick to well is still unsolved. The disease must, then, certainly be rather feebly contagious, for in none other is the recognized specific cause more abundantly found or given off in greater profusion from the body.

The bacilli are found in the nasal secretions, the saliva, the urine, and the milk of lepers. Coughing and sneezing scatter them far and wide. They are also found on the surface of open sores, and, either living or dead, must come into contact with thousands of healthy persons who do not subsequently develop leprosy.

The conditions favoring infection are not at all well understood. Physicians and nurses at leper hospitals are very seldom attacked; the disease often exists in a small center while neighboring communities, living under similar circumstances, both social and sanitary, are free. The theory that the dietary customs of certain peoples are essential to the maintenance of leprosy does not appear susceptible of proof, although Hutchinson has called attention to the undoubted fact that the principal centers of disease are among the fish-eating populations. Like other infections, leprosy flourishes best among the unclean, the underfed and

overcrowded, but the reason is probably that opportunities for prolonged and intimate contact between sick and well are most frequent with such people, so that sooner or later, and only in a comparatively few out of many inevitable contacts, viable germs find lodgment in suitable individuals, and disease results.

The most probable points of entrance are through the nasal mucous membranes, through skin-injuries or scratches attending certain skin diseases, and possibly also through skin-follicles and sweat-glands. Transmission by insects, by sexual connection, by handling fomites, by inhalation, and by swallowing must be considered possible, though not yet proved.

As the bacillus of leprosy has never been found elsewhere than in the patient's body, its secretions and its excretions; as culture experiments in the laboratory and attempts at inoculation on man and lower animals have been so barren of results, making it almost impossible to decide whether given bacilli are living or dead, we must not be too positive upon the conditions influencing infection. We only know that experience gained through centuries, and in many parts of the world, demonstrates that leprosy once introduced into a country is apt to spread; that its disappearance is hastened by improved social conditions of the population; that it has a predilection for the dark-skinned natives of warm countries; and that it is often of more virulent type in new centers. Most important of all, from the practical standpoint, is the knowledge that only by isolation or segregation of lepers can the disease be in time stamped out, and this without the necessity of reducing the unfortunate patients to the condition of total outcasts from society, as was formerly done. More complete knowledge of the contagiousness or infectiousness of leprosy will depend upon much greater success in the future in the laboratory handling of this very obdurate micro-organism than has been attained in the past.

That leprosy is inherited is not now generally believed, for the reasons that there is no fetal form and that few children of lepers become themselves leprous, certainly not more than intimate family intercourse would account for; nor do patients in the majority of cases give a history of leprous parents or relatives. Whether a predisposition to leprosy or a lessened resistance to infection is inherited is also open to doubt.

Varieties of Leprosy.—Leprosy occurs in two forms: nodular or tubercular leprosy, in which the skin lesions are the most striking symptoms, and nerve or anesthetic leprosy. Clinically the two varieties differ widely in symptoms and course of the disease, when of pure type, but most cases show symptoms of both forms, with sometimes one or the other greatly predominating. This mixed form of leprosy may exist from the beginning of the disease, or a well-marked case of the nodular variety will later show signs of nerve involvement, while very rarely, if ever, will nodules later develop in a case which has begun as a pure type of nerve leprosy.

Prodromal Symptoms.—Whatever form the disease may eventually take, the early symptoms of leprosy are by no means striking.

The site of the original infection is practically never known, and the time of infection, except in the rarest instances, can only be surmised. The period of incubation, if indeed it is proper to so name the long time during which the germs of leprosy lie latent in the body, giving no sign of their presence, is generally very long. In many recorded cases periods of from three to ten years, or even more, elapsed from the presumed time of infection to the actual first signs of disease. Shorter periods of incubation have been described—a few months or even weeks.

Prodromal symptoms of general constitutional disturbance are generally observed, but are often wanting. These vary very much in different patients, and are for the most part exceedingly indefinite and of slight diagnostic value. A rise of temperature is common at irregular intervals; the paroxysms of fever are indefinite in duration and in the degree of pyrexia. A sense of exhaustion and sleepiness, headache, pains in the back and limbs, digestive disturbances, nausea and vomiting are sometimes noticed. Slightly more definite are the nasal symptoms described by some authors, such as dryness of the mucous membrane, epistaxis, tickling, burning or pain in the nose. Sensory disturbances, such as localized anesthesia, hyperesthesia, itching, or intermittent neuralgic pains, are often present. A tendency to excessive sweating, either general or limited to certain regions of the body, is a symptom of considerable value. Sometimes a few scattered areas of limited extent show a positive anhidrosis, and later on in the disease these spots become anesthetic. The prodromal symptoms, indefinite as they are, may continue off and on for years, and of course may be attributed to many causes rather than the true one. In the tropics malaria will generally be suspected.

FIG. 549.—NODULAR LEPROSY IN FILIPINO, BEGINNING "LEONINE" COUNTENANCE (Dr. Victor G. Heiser, P. H. and M. H. Service, Manila, P. I.).

Finally, the first really tangible signs of leprosy appear in the shape of a macular eruption very variable in extent and appearance.

Nodular Leprosy.—Generally, after one of the febrile attacks of more than usual severity, reddish spots make their appearance upon the skin, especially on the face and extremities. The spots vary from the size of a pea to larger patches several inches square. The spots are either well defined or indistinct and are generally slightly raised. They may be

very numerous or few. The first spots usually fade out in a few days or weeks without leaving a trace, but new ones appear, of which some become a darker color, no longer disappearing on pressure. The spots are often the seat of itching or prickling and the hair disappears from the affected area. The scalp is never the seat of the eruption, but the early falling of the eyebrows is very noticeable in nodular leprosy, and the superciliary region is often the site of the first nodule. The development of the characteristic nodules takes place slowly, painlessly, and in a most irregular manner. They vary greatly in size, shape, and number, developing in some of the spots that have remained and become pigmented. At first there may be only one or two nodules, while later on successive crops appear. Some are no larger than a small pea, others the size of a walnut. The most common site is the face, especially the regions of the eyebrows; next, the backs of the hands, the fingers, the elbows, the knees, and the feet. The palmar and plantar surfaces are very rarely affected, the scalp practically never, but nodules may appear almost anywhere else in the body. In exposed locations, such as the face and hands, the growths are prominent and hard, but when subjected to pressure, as on the trunk, they are flattened and softer. The color of leprous tubercles is usually yellow-brown, but often a gray or violet tinge is observed. Neighboring nodules tend to become confluent, and in some situations there is no discrete nodule formation, but large areas of infiltrated skin are formed (lepromes en nappe) which may cover a great part of the trunk or may surround a limb. The new-growths come in successive crops, accompanied by fever and constitutional disturbance, during which the skin lesions are tender, swollen, and livid, but as the fever subsides the nodules shrink, and a period of distinct improvement occurs, lasting until the next febrile attack, with its new accession of nodules. During the periods of quiescence some nodules may disappear entirely, some grow very much smaller, and, in cases with only a few small tubercles, cures have been often reported. Sooner or later, however, renewed neoplastic formation may occur. The epidermis over the growth remains uninjured for a long time, becoming a little shiny and scaling slightly.

FIG. 550.—NODULAR LEPROSY IN FILIPINO. DISTRIBUTION OF NODULES (Dr. Victor G. Heiser, P. H. and M. H. Service, Manila, P. I.).

The tumors are confined for the most part to the true skin, but some extend to the subcutaneous tissues. A few indeed may begin in the deeper structures, and are felt as hard bodies through the intervening and ap-

parently unaffected skin, but usually the nodules are freely movable with the cutis. The nodules are subject to several changes. After a febrile attack with erysipeloid symptoms some of the smaller growths may disappear, generally leaving light or dark spots at the sites where they have been. When an intercurrent acute disease, such as true erysipelas, attacks the leper, the nodules, if not too large nor too numerous, may all disappear. Impey,[5] indeed, states that a real cure may thus take place. The growths may also undergo softening and ulcerate. The ulcers are painless and indolent, healing slowly and leaving anesthetic cicatrices. The non-sensitive leprous nodules are subject to many small traumatisms which the patient does not notice at the time, and much of the ulceration is due to such injuries. When the nodule formation has gone on for some time, the well-known and often described leonine countenance is developed. The infiltrated skin of the forehead, greatly thickened, is deeply furrowed, giving a massive and frowning appearance; new growths elsewhere on the face cause the nose to appear flattened, the lips and chin to become protruding and knotty, the ears distorted and thickened. The play of the facial muscles is destroyed so that the expression is mask-like and fixed. Along with the changes in the skin the mucous membranes of the nose and mouth are also the seat of new tissue formation, which is more liable to soften and ulcerate than is the case with skin nodules. The nostrils become occluded, respiration is interfered with by laryngeal infiltration, and swallowing is rendered difficult from involvement of the pharynx and esophagus. The patient speaks with a raucous voice which is very characteristic. The nasal cartilages may be destroyed, causing the nose to sink in or become distorted. The destructive processes due to ulceration may of course lead to directly fatal consequences, or in cicatrizing great deformities may result. The eyes and their appendages often suffer greatly in leprosy; the eyelids may become infiltrated, ulcerate and cicatrize, leading to frightful disfigurement; the conjunctiva becomes the seat of numerous small tubercles which later invade the cornea, or else the deeper structures of the eyeball are invaded first; in any case total blindness is the result.

During the course of the disease the lymphatic glands of the body enlarge and may soften, each new crop of nodules being attended with intensified swelling of the neighboring glands. The decline of health and strength in lepers is very slow but progressive. The appetite remains good for a long time; taste and smell are retained surprisingly well even when the nose and mouth are considerably diseased, but are finally lost; the mental faculties are entirely unaffected. Unless some intercurrent disease mercifully puts an end to the patient's life, the late stages of leprosy will present an unspeakably loathsome picture. Mentally able to appreciate to the full his pitiable condition, the leper drags on his life, blind, speaking in a harsh whisper, without smell, without taste, crippled it may be, an offense to the sight of man. What wonder, then, that leprosy has been placed supreme among the greatest evils with which mankind has been afflicted!

Anesthetic or Nerve Leprosy.—The prodromal symptoms of nerve

leprosy are very much as described for the tubercular variety. Perhaps with the fever and constitutional disturbance there will be more marked nervous symptoms of various kinds. Pain of a neuralgic character, often very severe, occurs generally in paroxysms and may affect almost any part of the body. Other common symptoms are itching, burning, and numbness. Sometimes the whole body is in a state of hyperesthesia, so that pain is induced by the slightest contact or on movement. Vasomotor disturbances, such as flushing of the skin and slight transitory edema of limited areas, have been described. Vertigo is often observed.

The prodromal signs of nerve leprosy are, however, quite frequently extremely slight, and are often overlooked by the patient and his physician. Sometimes the very first symptom is a simple loss of power in the upper extremities with no other manifestation of the disease. The macular eruption of nerve leprosy presents some points of difference from that of the nodular variety. The spots develop symmetrically on the trunk and limbs, often following the course of large nerve-trunks. The patches are erythematous, disappearing on pressure, pigmented and not so disappearing, or dead white, like vitiligo. The centers of the spots often become decolorized while the peripheries are deeply colored and slightly raised. The pale centers are partly anesthetic, generally retaining tactile sensitiveness, but are insensitive to pain and heat. As in nodular leprosy, some of the patches disappear entirely, some become pigmented and remain, and new spots appear from time to time. The duration of the macular stages of nerve leprosy may be extended to years before serious signs of nerve involvement show themselves. Very characteristic of nerve leprosy and occurring during this stage is the appearance of bullæ (pemphigus leprosus). After a slight rise of temperature with increased neuralgic pain a bulla forms, rarely more than one at a time. It appears on skin not previously affected, or at the site of a macule, and varies in size, often being as large as an egg. The contained fluid is serous, but becomes rapidly purulent, and the surrounding skin is reddened for some distance. The bleb ruptures and dries up, afterward desquamating, and finally leaving a pale anesthetic spot, with a thin, well-marked, brownish border. Oc-

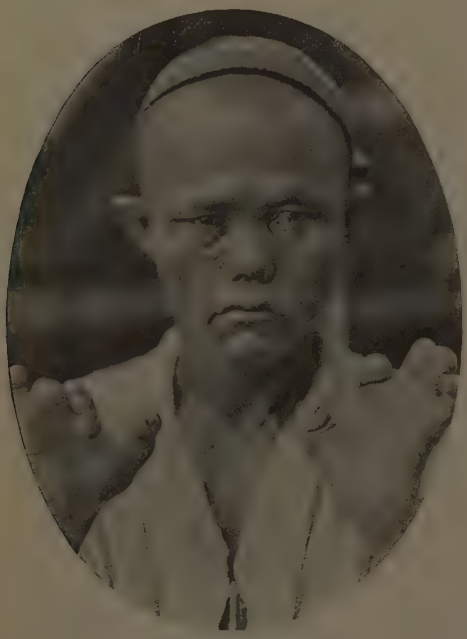

Fig. 551.—Nerve Leprosy. Pure Type (Münch).

casionally the site of the bulla ulcerates and then becomes covered with a brown rupial crust, the final cicatrix being shining white and contracted or rarely keloidal in appearance. The bullæ are most frequent on the backs of the hands and feet, the elbows, the knees, and the back. They may come in successive crops to such an extent that the body of the patient is covered with their remains in different stages of cicatrization, and indeed death, when the eruption is of such a violent nature, may result. The macular and bullous eruptions are the beginning of a true bacterial nerve infection, rather than the consequence of a neuritis already existing, for in this form of leprosy the bacilli, instead of infiltrating the skin and forming nodules, invade the terminal nerve-endings and the larger trunks from without inward, giving rise to a great variety of symptoms. Neuralgic pains and the other disturbances of sensation become more marked, such as itching, burning, hyperesthesia, spots of anesthesia, etc. The cutaneous lesions may now continue to disappear wholly or in part; but the signs of serious nerve involvement are from this time on progressive. The regions supplied by the ulnar, the peroneal, the anterior tibial, the sciatic, and the trigeminal nerves are usual sites of the paresthetic or painful symptoms, especially the two former localities. Where these nerves can be felt, as when they pass over a bone, the nerve-trunk is found to be hard, thickened or nodulated, and very sensitive to pressure. This, the first or irritative stage of nerve involvement, slowly subsides, to be followed by degeneration and destruction of the nerve substance with all of its natural consequences. Both motor and sensory trunks are attacked, the result varying, of course, with the nerves affected and the degree of destructive action. Anesthesia, which in the early stages is confined to the spots or to very limited areas, when the large trunks and central nervous system are attacked becomes a dominant feature of the disease. The anesthesia of the macules is due to a terminal neuritis only and may disappear, but the later anesthesia, due to disintegration of nerve-trunks or lesions of the cord and spinal ganglions, is permanent, progressive, and may be total. The loss of sensation nearly always begins in the extremities, rarely in the face. Later on the trunk is affected in a small proportion of cases.

On the supposition that nerve leprosy is a centripetal process, anesthesia limited to small spots is caused by bacterial invasion of terminal nerve-ends; zones or bands of anesthesia occur when trunks are involved, and segments of the body are affected when there are lesions of the spinal cord. The anesthesia is often strikingly symmetric, although not invariably so; it is at first partial, variable, and superficial, but after a time it is deeper, more absolute, and tactile sensation is totally lost in the affected areas as well as the sensations of pain, heat, and cold.

Along with the loss of sensation trophic changes take place in the regions supplied by the diseased nerves. The hair rapidly thins out over the affected areas until complete depilation results, although the scalp is not attacked. The skin is hard and dry as a result of suppression of sweat; it also becomes thin and cracks. The nails atrophy and become deformed; trophic ulceration is developed on surfaces exposed to pressure

or injury, the most common site being the sole of the foot, where a perforating ulcer often occurs. The fingers and toes may be attacked by a penetrating ulceration and be totally destroyed. The pathologic process is either a periostitis surrounding the phalanx, in which case the bone necroses and is extruded, or an obliterating arteritis which may lead to the loss of a digit from dry gangrene. The phalanges may possibly undergo total absorption without loss of the soft parts, or the lime salts of the bones may so disappear that the shafts may be bent in any direction. The muscles supplied by the diseased nerves atrophy and lose power. The first wasting is commonly observed on the palmar aspect of the hands, all eminences disappearing so that the smooth simian hand of the Aran-Duchenne type is produced. The atrophy extending to the interosseous muscles and the extensors of the fingers gives rise to the often described main-en-griffe. In the lower extremities the peroneal and extensor muscles are affected, causing locomotion to be difficult. The muscles of the arm, thigh, trunk, and face may be later attacked, and should the muscles of a region be affected in an irregular fashion, which is sometimes the case, curious distortions are observed, especially in the face, for when one or two muscles of expression are left intact among many paralyzed ones, a characteristic grimacing countenance results—the *mask* of nerve leprosy. The eyes remain wide open from muscular paresis; ocular deviation of all varieties may occur; there may be ptosis or ectropion. Excessive lachrymation from exposure of the eyeball is followed by suppression of the secretion, when the eyelashes will drop out and the eyeballs become horny and dry. Small opacities form in the cornea which coalesce, or else ulceration and perforation occur with gradual progression toward total blindness. Ulceration of the nasal mucous membrane may take place with destruction of the septum, so that the nose sinks in, as in nodular leprosy. The mucous membranes of the mouth may also ulcerate, the gums recede, and the teeth drop out. Anesthesia of the tongue and mucous surfaces and paralysis of the buccinators interfere with mastication. The lower lip falls from paralysis of the orbicularis and saliva flows continuously.

The course of nerve leprosy is therefore entirely different from that of the nodular type. It is very much slower, for patients with nerve leprosy of pure type may live for several decades and attain ripe old age. Fortunately the progression of the disease toward the last terrible stages of mutilation, paralysis, and atrophy is not inevitable. The malady may be arrested for years; in the milder cases, indeed, after a certain amount of nerve involvement, the disease seems to cease entirely. Perhaps the bacilli have in such instances died out; certainly their presence can no longer be made out by any diagnostic method known to us. The damage to the nerves is done, but the patient is no longer, strictly speaking, a leper. Death seldom occurs as a direct result of the leprosy, but usually from an intercurrent pneumonia, acute pulmonary tuberculosis, bronchitis, or organic disease of the kidneys. A common termination of life is from an acute choleraic diarrhea.

Mixed Leprosy.—It is the rule for the two types of leprosy to be found

in the same patient before the end of the case, and one or the other may of course greatly predominate. Sometimes the skin and nerve invasion by the bacilli go on together from the beginning, or, as is common enough, nerve involvement comes on later in a well-marked case of nodular leprosy, but it is exceedingly rare for nodules to occur in a case which has begun as a pure type of nerve leprosy. The combination of symptoms which may occur in mixed leprosy varies so infinitely in different patients that it is useless to attempt to further describe this form of the disease.

Based on a large clinical experience, Black [6, 7] has recently suggested a reason why leprosy sometimes assumes one clinical form and sometimes another. He believes that the initial lesion of the disease is a trifling ulcer somewhere on the nasopharyngeal mucous membrane: if the ulcer heals and only a few bacilli gain entrance into the general circulation, anesthetic leprosy alone results; if, on the other hand, the nasal ulcer grows and very many virulent germs are continually disseminated throughout the body, infiltration of the skin and subcutaneous tissue, or even invasion of internal organs, also takes place. In other words, nodular leprosy is anesthetic leprosy plus invasion of the skin and other organs by active organisms. A careful study of the symptoms of the several varieties of leprosy shows that this theory is very plausible, but unfortunately the initial nasal lesion has not yet been demonstrated. Should it ever be, the great problem of leprosy—its method of infection—will be in a fair way to be solved, and the prospect of cure by early treatment be greatly increased.

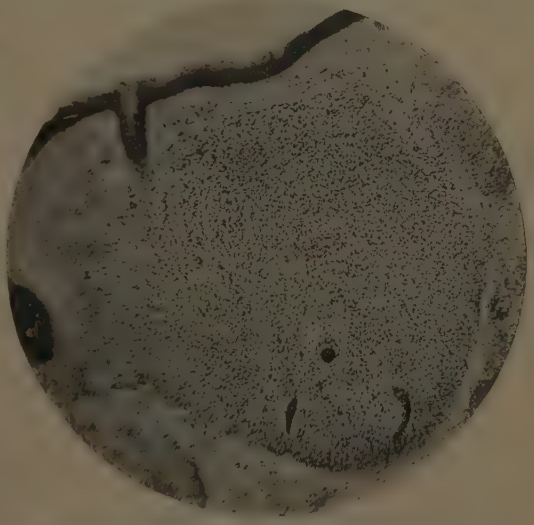

FIG. 552.—NODULAR LEPROSY. CELL INFILTRATION IN YOUNG LEPROMA. LOW POWER (Army Med. Museum).

Pathologic Histology of the Lesions.—The outward appearance of leprous nodules has already been described. A leproma, if recent, shows on section a white, shiny surface; if older, a reddish or brown color, and the cut surface exudes a thin sticky fluid on pressure, the so-called "leper juice." The neoplasms of leprosy are granulation tumors, histologically resembling the gummata of syphilis and the tuberculous growths in certain varieties of lupus. They are quite vascular and are formed by an infiltration into the corium of round cells and epithelioid cells which at first arrange themselves in a network in the con-

nective-tissue spaces immediately surrounding the blood-vessels of the skin. The infiltration becomes thicker and denser, occasionally extending to the subcutaneous tissues, but not affecting the epidermis. The glands of the skin and the hair-follicles are so crowded by the new-growth that they atrophy and disappear. Along with the new cells are the bacilli of leprosy, usually in enormous numbers. They are found free in the lymph-spaces and also within the cells; sometimes discretely disseminated, but most often in bundles of rods or in relatively enormous bacillary masses. There is still difference of opinion as to whether the bacilli are found intracellularly or not; Unna[8] maintaining that they are not so found, and that the bacillary masses are zooglea formations; Hansen[9] teaching that the organisms are nearly always within the cells. Many of the latest observers combine both views. The most striking appearance in a section of an old leproma is the presence of brown or yellow flakes, either round or oblong, disseminated throughout the neoplasm, and when plentiful, giving the section its brownish color. These are the "globi" of Hansen, who considers them to be masses of bacilli occupying cells and which, having died out, are partly disintegrated and of granular appearance, so that little of the structure of the micro-organisms can be made out. According to Unna, the "globi" are cross-sections of bacterial thrombi of the lymph-vessels.

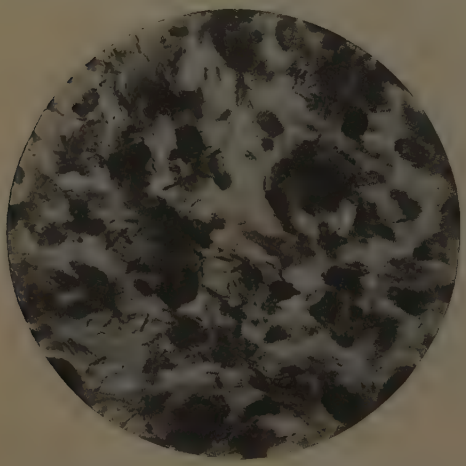

FIG. 553.—NODULAR LEPROSY. DISTRIBUTION OF BACILLI IN LEPROMA. × 900. HIGH POWER (Army Med. Museum).

The opinion of those who hold to both the intracellular and extracellular proliferation of the bacilli in leprous tissue is summed up by Jeanselme[10] about as follows: (1) Bacilli from the terminal blood-vessels of the skin collect in the neighboring lymph-spaces and provoke a gradual infiltration of round and epithelioid cells. (2) The bacilli penetrate the new cells and form large intracellular colonies which distend the cells, the protoplasm becoming vacuolated; these are the "lepra cells" of Virchow, or when very large, with numerous nuclei, the giant cells described by some observers. (3) The bacilli left in the lymph-spaces multiply and mass together, finally becoming disintegrated and structureless in appearance, thus forming the "globi," which appear round or oblong according to the direction in which the lymph-spaces or vessels are sectioned in the specimen. The "globi" are always found most plentifully in the upper strata of the nodules and increase in number with the age of the leproma. Vacuole formation is a common occurrence in them, indicating complete destruction and liquefaction of the micro-organisms.

In the macules of early leprosy it is probable that at the beginning the same pathologic process is initiated as in nodule formation, but with comparatively few organisms, so that when the infection is not active the bacilli present may be destroyed by connective-tissue production, and in such spots no further tissue changes are to be expected. Some spots, as we have seen, may become the site of future nodules, or a case of pure nerve leprosy may develop where the nerve terminals alone are attacked by the bacilli, and no skin infiltration takes place beyond the production of the macules. It is exceedingly difficult to find bacilli in the macules; they are, indeed, absent from the old spots, but are to be found, by careful technic, sparsely scattered through the tissues in the fresh ones. The spots show some infiltration with smaller cells, but large cells and "globi" are not found as a rule. In anesthetic spots the nerve terminals are degenerated. In the nerve lesions the bacilli are found in the peripheral part of the nerves, the perineurium and the endoneural septa showing the greatest tissue changes, especially in the neighborhood of a vessel,[11] and where "globi" are found they are in the same situations. The leprous process may confine itself to the perineurium and the endoneural septa (cell-infiltration, proliferation, etc.) in mild cases, but, on the other hand, the process may go on until all the nerve-fibers are fused together in a bundle and a mere fibrous cord results. The epineural connective tissue is singularly free from bacillary invasion, but bacilli are occasionally found in situations where traumata are common, as, for instance, where the ulnar or the peroneal nerves cross bony structures. The number of micro-organisms in nerves varies greatly according to the case and the stage of disease, but it is never as large as in nodular leprosy. The leprous process is similar in the perineurium and endoneurium to that already described in skin leprosy—"globi," vacuolated cells, and the same retrograde changes occur. In the epineurium the "globi" are scarcely ever found and bacilli are very few. Even before the discovery of Hansen's bacillus changes in the spinal ganglia and the cord itself were described as occurring in this disease, generally a sclerosis of the posterior columns or gliosis, as in syringomyelia. The bacilli are found in the ganglia and in the cord, but there are no constant pathologic changes of importance. The fact that syringomyelia of the type known as Morvan's disease clinically closely resembles anesthetic leprosy has caused the theory to be advanced that it is really nothing but a special type of anesthetic leprosy—an opinion by no means generally accepted. The lesions of mixed leprosy and generalized leprosy where various organs of the body are attacked by the leprous process would require a volume to adequately describe them. The lungs are sometimes the seat of leprous tubercles which are easily confounded with true tuberculosis, and here it must be remembered that tuberculosis is a very common complication of leprosy. The liver, the spleen, the bone-marrow, and the testicles are not infrequently invaded by the disease. The kidneys are rarely attacked, but are subject to amyloid and other degenerations which are often the cause of death.

Diagnosis.—Leprosy is not easy of diagnosis in its early stages;

in countries where it is rarely found, and therefore not expected, a diagnosis is practically never made until the disease has progressed very far, and even in centers of leprosy early diagnosis is not common. The premonitory symptoms are, as we have seen, very indefinite and signify little until the spots appear. Falling of the eyebrows with the appearance of a small nodule in the same region is a suspicious symptom, and in nerve leprosy the thickening of the ulnar nerve at the elbow. The spots are suspicious if they are anesthetic and do not sweat. An eosinophilia has been described in nodular leprosy, but it is not a very important symptom. Spinal puncture in nerve leprosy has some diagnostic value as indicating, if a lymphocytosis is present, a meningeal irritation. The successful demonstration of the specific bacillus is, however, the only perfectly satisfactory sign of leprosy: an easy matter in the nodular variety, and a very difficult one in nerve leprosy. In countries where the disease is common all cases of skin disease, monoplegias, localized anesthesias, or muscular atrophies must be examined with a view of their possibly being leprous. The differential diagnosis between leprosy and syringomyelia might in certain rare instances be impossible, but with a macular eruption and enlarged nerve-trunks syringomyelia should be excluded.

Prognosis.—The prospect of complete recovery in leprosy is, it must be confessed, extremely slight. It is the rule in nodular leprosy for the disease steadily to progress, notwithstanding the fact that periods of great improvement are common enough, during which a cure is confidently predicted or even claimed. In a few carefully recorded cases where the disease has been treated early, before the appearance of many lesions, all signs of active infection have premanently disappeared, and it is difficult to avoid claiming these cases as cured. In nerve leprosy, as has been stated, after certain damage is done, which of course is irreparable, the disease seems to become entirely arrested and the patient may live to a ripe old age.

Treatment.—As in tuberculosis, improvement and possible arrest of the disease may be hoped for through improved nutrition, fresh-air life, and cleanliness. At all events the most careful hygienic treatment of lepers is demanded for the sake of humanity and for the protection of the public health. As for drugs, in no disease have so many specifics been confidently announced from time to time, only to disappear, when further experience had demonstrated their uselessness. The unfortunate leper takes, and is richly justified in taking, any remedy which offers him the slightest hope of amelioration. If he is using a special drug about the time that one of the not uncommon periods of exacerbation occurs, and if, as is also the rule, a marked improvement takes place, the reputation of the remedy is great until time has demonstrated its failure to make any lasting impression on the course of the malady. At the present time the specific which has preserved more of its reputation than any other is the ancient Chinese remedy, chaulmoogra oil, administered in capsules of from 10 to 40 drops several times a day. The oil is pushed to the point of toleration, and can also be given by inunction mixed with some other oil, by enema mixed wth milk, and by hypodermic injection. There is no

question but that great improvement and several apparent cures have followed the persistent use of this remedy. Isadore Dyer,[12, 13] of New Orleans, the best-known American authority on leprosy, uses the following treatment: Chaulmoogra oil, in as crude a state as possible to obtain and yet have it in liquid form, is given in capsules or in milk, beginning with 3 drops several times a day and gradually increasing until 120 or 150 drops are taken at a dose, and preferably before meals; full diet; hot baths—on which he lays great stress; febrifuges as needed, and appropriate treatment for intercurrent diseases. Strychnin is considered a *sine qua non* in all cases. Persistence in treatment in spite of discouragement is, according to Dyer, sometimes rewarded by a cure even when the improvement only begins to show itself after months or years have elapsed with no apparent result. Unna reported several cures from the internal use of ichthyol, with pyrogallic acid and chrysarobin used externally.

Attempts to treat leprosy by serum-therapy have been made repeatedly, but so far with little success. Tuberculin seems to aggravate the symptoms, but of the several anti-leprous serums, although none have been prepared entirely from the specific bacilli of leprosy, a culture of which has so far been unobtainable, nevertheless distinct improvement has been in many cases attained by the original investigator, while others have failed to note any good results. Carrasquilla[14] injected horses with serum from lepers and reported improvement in leprosy patients from injections of the serum of the horses so treated. As Metchnikoff and Besredka obtained equally good results from the serum of a goat which had been injected with defibrinated blood from a perfectly healthy man, the serum of Carrasquilla is certainly not an antitoxic serum in the usual sense of the word. Rost, of the Indian Medical Service, is the last to have produced a serum from which great results were hoped, and in fact seemed at one time to have actually been obtained. He believed that he had succeeded in growing the B. lepræ in salt-free media, and from these supposed pure cultures he prepared his "leprolin," the use of which was followed by such favorable reports from other investigators, as well as from himself, that to the outside world it really seemed that the problem of the cure of leprosy had been solved. The cultures were soon proved, however, not to be B. lepræ, and the "leprolin" on which so many hopes were founded is no longer made. Calmette's antivenine has given good results in the hands of Dyer,[12] but the limited amount available and the difficulty of getting it fresh prevent its general use.

Surgical measures to eradicate the leprous lesion have been undertaken repeatedly. Thus macules of early appearance have been excised, and the first tubercles have been destroyed by the actual or galvanic cautery. The results of such early action have not been particularly encouraging, but it certainly seems good practice, where the lesions are few and seen early in the case, to destroy the centers from which the infection is evidently spreading to surrounding tissue.

The use of the *x*-rays on the growths in nodular leprosy seems, in selected cases, to promise very well. If not a cure, at least great improvement results. In 1903 a soldier of the United States army,[16] with

fairly well-advanced nodular leprosy, was subjected to the treatment by the *x*-rays. No changes were observed until from seven to ten exposures had been given. Then, after a dermatitis with exfoliation of the skin, the smaller nodules began to disappear, leaving areas of brown and shining skin; the larger nodules diminished very much in size, but did not totally disappear; the fever and constitutional symptoms improved to a marked extent under the treatment. Urbanowicz[17] reported nine cases treated with the *x*-rays with improvement in all the tubercular cases, but with injury to the anesthetic patients. He found also that ulcers deepened under this treatment, and therefore considers it admissible only for early cases of nodular leprosy with few neoplasms. Wilkinson,[18] of the Public Health and Marine Hospital Service, reports from Manila thirteen cases, of which three were cured, seven improved, and three not improved. He believes that the organisms killed at the spot are absorbed and produce a certain amount of protection, as improvement of lesions at a distance from those exposed to the rays was marked. Altogether the use of *x*-rays in leprosy appears worthy of more extended trial.

The treatment of leprous ulcers by surgical means and by the usual antiseptic or disinfectant dressings calls for no special mention, such procedure being, of course, necessary to the patient's comfort as well as indicated to prevent the infection of others. Where extensive ulceration has caused an extremity to be practically useless, amputation is sometimes called for. Surgical operations undertaken upon lepers are, as a rule, quite successful, for even when the incision must be made through infiltrated tissue, healing is usually prompt and firm.

For the relief of pain, muscular atrophy, and other symptoms of anesthetic leprosy various surgical procedures have been advocated: nerve-stretching or division, or scraping out the diseased perineurium. No permanent benefit is to be expected from such action, but in exceptional cases it may, of course, be strongly indicated.

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TROPICAL DYSENTERY.

The disease, or rather symptom-complex, known as dysentery is found in cold and temperate as well as in hot countries, but in tropical and subtropical regions it is both much more common and much more severe. It frequently occurs in limited areas endemically, and is recognized as the greatest danger to health in some particular place, although other spots with similar climatic conditions may have no such bad reputation. In the endemic areas the disease is sporadic, though very common. It is apt to be insidious in attack and subacute or chronic in its course, with occasional acute exacerbations of all the well-known symptoms. Again, dysentery occurs in acute and fulminant form epidemically, and armies in the field, prisons, and asylums are swept by what is evidently a rapidly infectious disease, this occurring in any climate and at any season of the year. The former or endemic variety is rare in cold climates, but widely spread in warm, and is generally meant when the term "tropical dysentery" is used.

Classification.—Dysentery is an inflammation of the large intestine accompanied by abdominal pain, tenesmus, and frequent scanty stools of mucus and blood; clinically it is acute, subacute, or chronic; pathologically it may be catarrhal, ulcerative, diphtheritic, or gangrenous; etiologically there is as yet no satisfactory classification, for in its various forms it has certainly several and perhaps many exciting causes. Recognizing that there are other specific agents, both bacterial and protozoan, very probably capable of giving rise to dysentery, at the present time we can conveniently divide the disease into three classes, which undoubtedly include the great majority of all cases.

First: *Catarrhal colitis* or *enterocolitis* without known specific cause, originally due or partially due to improper or undigested food, exposure, chill, etc., generally acute and of short duration, yielding readily to treatment, but occasionally going on to ulceration and running a chronic course. These cases perhaps should not be considered dysentery at all, but as the classic symptoms, abdominal pain, tenesmus, bloody and mucous stools are present, the diagnosis is generally so made. It is common in the tropics and furnishes a small proportion of the chronic invalids sent home from our Philippine possessions.

Second: *Bacillary dysentery*, sporadic or epidemic, usually acute, often rapidly fatal, and due to the B. dysenteriæ of Shiga[1] or some other strain of the same bacillus, of which there are several types differentiated by their action upon various sugars, and by the agglutinative power of immune serum upon pure cultures.[2, 3, 4] This is the epidemic form of dysentery that has devastated camps, asylums, and prisons. It is a cosmopolitan disease, but is often found in the tropics, where it is especially grave in type. The disease is generally self-limited, but chronic dysentery following acute attacks is not very rare.

Third: *Amebic dysentery*, caused by the Amœba dysenteriæ (A. coli), acute, subacute, and chronic, and if acute almost always terminating in a chronic condition. This disease and malaria cause nearly all of the

physical human wreckage sent home from tropical countries. If not as common as malaria, it has cost the United States the permanent loss of valuable officers and enlisted men to a far greater degree than any other "tropical disease."

With acute dysentery surgery has nothing to do except in the rare event of complications, such as intestinal perforation, intussusception, or an abscess somewhere in the abdominal cavity. These complications are treated on the same general principles as when they arise in connection with any other disease.

In chronic dysentery, however, surgical treatment offers a valuable and, I believe, a too much neglected means of benefit or cure. Suitable for selected cases of chronic colitis, no matter how caused, surgical treatment is generally called for in chronic amebic dysentery, and a short description of this form is here necessary. In most of the chronic cases seen in the United States, or returning from the tropics, amœbæ will be found in the stools either constantly or when the acute exacerbations take place.

Causes.—Amebic dysentery is a colitis, rarely an ileocolitis, caused by the A. dysenteriæ of Councilman and Lafleur (A. coli, Loesch, Entamœba histolytica, Schaudinn), considered by most authorities zoölogically different from the amœba often found in the stools of healthy men, to which alone the name A. coli is given. Whether all amœbæ found in the human intestines are potentially pathogenic, or whether there are two recognizable varieties, harmless and disease-producing, is yet a matter of doubt. Schaudinn[6] described the pathogenic amœba (Entamœba histolytica) as morphologically different from the non-pathogenic (E. coli). On the other hand, Musgrave and Clegg,[7] of Manila, consider all intestinal amœbæ potentially pathogenic and believe there are several varieties. Amœbæ are successfully cultivated in the laboratory only in symbiosis with various bacteria. This leads to the interesting question as to just what effect association with the bacteria of the intestines may have on their pathogenic powers. Clinically, amœbæ from the stools of dysenteric patients generally include red blood-cells, while those from healthy men do not. This valuable diagnostic sign does not prove, however, that the two organisms are different, but only that one is active in a pathologic process, and the other is apparently doing no harm. There are no other certain means of distinguishing the two by the clinical microscope at any rate. Abscess of the liver is a common complication of amebic dysentery in which the organism plays an important part, so that with reason Musgrave and Clegg[7] have suggested the term "amœbiasis" for pathologic conditions due to amebic infection, regardless of location.

The parasite is water-borne, or may be conveyed by contaminated soil to the mouth by dirty hands or from eating green vegetables grown in sewage-polluted ground. Amœba dysenteriæ is readily found in the stools of most patients, and when plentiful it suffices to examine a little flake of mucus from the stool. Usually it is best to give a dose of saline cathartic and examine the fluid portion, for not only will the saline scour away amœbæ from the mucous membrane in cases where none are coming

away in the regular stools, but the organisms so secured are more active in movement.

FIG. 554.—TROPICAL DYSENTERY (W. W. Gray, Army Med. Museum).
Movements of an ameba, photographed at ten-second intervals; several blood-cells are included in the parasite.

The parasite is from 15 to 20 μ in diameter, having an outer zone (ectosarc) which is very clear, and a granular inner area (endosarc) containing a nucleus, several vacuoles, and perhaps foreign bodies, such as bacteria, blood-cells, and food detritus. It moves by putting forth protrusions of the ectosarc in various directions, for a time not changing its location, until presently the endosarc gushes forth into an unusually long protrusion and the amœba moves across the slide. It may be stained in various ways, but the presence of the characteristic movements is necessary to prevent mistaking the organisms for other objects under the lens, so that fresh specimens examined on a warmed slide must be used for diagnosis.

Pathology.—The intestinal lesions of chronic amebic dysentery are found in the large intestine throughout, occasionally also in the last portion of the ileum. At first the submucous tissues are edematous, and the fixed cells multiply, leading to an infiltration which elevates the mucous membrane in rounded patches. The membrane dies and is cast off, leaving a jelly-like grayish slough, which, after a while, comes away, exposing the muscular coat of the gut. The ulcers so formed are small or large, round, oval or irregular, and of varying depth according to the stage of ulceration. They penetrate to the submucous, the muscular, or the serous coat, and perforation is not very rare. The ulcers are either distributed throughout the whole of the large intestine or are limited to certain parts; the cecum, the flexures of the colon, and the rectum being places of election. The summits of the intestinal folds are common sites of the ulcers. The edges of the ulcers are thickened and edematous. What appears to be healthy membrane has often been undermined and merely bridges over ulcerated tracts communicating with other ulcers. For this reason large pieces of membrane are frequently thrown off in mass. The disease advances more or less slowly, attacking new tissue, while the older ulcers make attempts at cicatrization. Some heal by the formation of fibrous tissue, which may constrict the lumen of the bowel. In a general way infiltration, ulceration, sloughing, and reparative processes are going on simultaneously in the various affected parts, giving an infinite variety to the gross appearances seen at autopsy, and accounting for the varied symptoms that characterize chronic dysentery through its slow course. Amœbæ are found in the tissues around the ulcers, in the lymph-spaces, and in the small blood-vessels. Secondary invasion of the lesion by various bacteria is, of course, inevitable. Infection of the liver in cases of amebic abscess probably takes place through the portal vessels, where indeed the parasites have actually been found.

Symptoms.—The symptoms of chronic dysentery vary with the extent of bowel involvement, the acuteness of the morbid process, and with the time for which it has been going on. Most of the patients returned to the United States have been suffering for months. The cases may have begun acutely, but more frequently they have been subacute from the first, soon assuming the chronic form. Emaciation and great debility develop as the case progresses. Periods of improvement and almost apparent recovery occur, and the patient's hopes are raised, only to be

dashed to earth again by the advent of a sharp exacerbation of pain and bloody flux. Some suffer most from abdominal pain, some rather from tenesmus, according to the parts of the bowel involved. The most favorable cases improve until the general health is almost normal, the body-weight is recovered, the face has a fairly healthy color, the appetite is good and the strength sufficient for not too arduous work. By careful diet and considerable self-coddling such a patient may keep himself free from pain, and even arrive at the point where he has only one or two nearly normal bowel evacuations per day. Nevertheless he is not well; a little mucus may follow his apparently normal movements; he is still unable to do a day's hard work; an imprudence in eating is followed by pain and flux; if the disease has affected the rectum, precipitate or even involuntary movements are always imminent. In short, he is a semi-invalid at the best, with the constant expectation of falling into a worse condition. The average patient is by no means in even as favorable a state as this. He remains thin, anemic, and feeble, with several painful stools a day, and progresses slowly though steadily down-hill.

Treatment.—The usual treatment of chronic amebic dysentery is satisfactory only in that much improvement or a partial cure is often effected. So many supposed recoveries have been followed by disappointment, so many times improvement has been succeeded by relapse, that it is the rule to find the physician with the most experience to be the most pessimistic in prognosis. There are indeed some recoveries, but many more cases that stop short of recovery. Diet, nursing, and rest are, of course, very important in all cases; in fact, with no other treatment the patient may improve to a considerable degree. Many patients gain greatly during their voyage home from the Philippines. Medicines by the mouth have a very limited value in chronic dysentery. Intestinal antiseptics so given are unsatisfactory; opiates are only useful to relieve pain, and bismuth may be actually harmful by coating the ulcerated bowel, allowing the amœbæ to flourish beneath and preventing any remedy from coming into contact with the lesions.

As may be readily seen from our knowledge of the pathology of the disease, treatment must have two objects: to destroy the parasites if present, and to help cicatrization. Granting that all the organisms can be destroyed, it by no means follows that the second object will be attained, for there are obstinate cases of chronic dysentery without amœbæ. It seems evident that both objects are best approached by local treatment of the ulcerated gut—surgical treatment for a surgical condition.

Irrigations[9] by the rectum, with solutions, cleansing, antiseptic, and lethal, to the amœbæ, have long been used with good effect. Injections must be massive and distend the gut thoroughly to be really effective, as the whole mucous surface of the large intestine should be reached by the irrigating fluid. They should be administered by means of a glass irrigator, and the tube should be several meters in length, the rectal tube alone $\frac{3}{4}$ of a meter long and of fairly stiff rubber. The irrigation is to be given with the utmost gentleness and skill, and it is by no means an easy procedure to carry out satisfactorily. The patient lies in the

Sims position, with the hips elevated and the foot of the bed raised. The rectal tube, well lubricated, is introduced gently, the flow turned on at low pressure, and the tube carried up slowly. Even when the operation is skilfully done the pain may be very great, so that but little fluid can be introduced. In some cases patience and the use of small injections at first, gradually increased from day to day, will lead to final tolerance of a sufficiently large amount of fluid, but many patients cannot or will not bear the pain, and the treatment must be abandoned. Where the irrigations are well borne and the fluid can reach all of the affected area, the results are most gratifying and prompt. Two liters or even more ought to be tolerated in most cases, but the maximum amount must be learned from cautious experiment, and the fluids should be retained ten or fifteen minutes. When the rectum is very irritable, a preliminary small injection of an anodyne solution containing cocain, morphin, or tr. opii may be called for; where the bowel is manifestly loaded with feces or is distended with gas, an irrigation of plain warm water is first used, afterward the medicated fluid. Many drugs have been recommended: Argyrol 1 : 1000, protargol 1 : 100, silver nitrate 1 : 2000, hydrogen peroxid 1 : 10, acetozone 1: 1000, etc., but the most generally useful is quinin sulphate in 1 : 750 to 1 : 1500 solution. Quinin is very lethal to the amœbæ even in these weak solutions, but stronger solutions are used by some. Manson recommends silver nitrate 1:1000 after preliminary cleansing irrigation, in cases where acute symptoms are absent. The drawbacks to the treatment by rectal irrigation are the trouble of administration, the pain caused, and above all the difficulty of reaching all the lesions.

Operative treatment by lavage of the large intestine through an artificial opening into the gut is not a new suggestion, but as first used was an operation of last resort. An artificial anus was established for the purpose of giving the colon complete rest and at the same time allowing irrigation to any extent desired from above downward. The radicalness of this measure has not found favor with many surgeons, but recently a much less objectionable method suggested by Weir[11,12] has been devised which deserves more attention than it has yet received. It consists in using the appendix when it is healthy, freely patulous, and of sufficient caliber, or of opening the cecum directly, providing, as in the operations of gastrostomy, against leakage of the intestinal contents.

By this method, it is true, the colon is not given complete rest, but the patient is not rendered an offense to himself and others; the daily irrigation becomes the only daily evacuation and the small fistulous opening, when no longer needed, will generally close of itself or require a very slight reparative operation. In the general hospitals of the army and at the United States Soldiers' Home in Washington the operation has become well known, and is often done at the earnest request of patients who have seen the relief it has given others. This last institution has many chronic cases of amebic dysentery in young men returned from the Philippine Islands, who have reached a fairly satisfactory state of improvement, but have stopped short of cure. They must remain hospital pa-

tients, be dieted, nursed and treated. They can never hope to do a hard day's work or be other than semi-invalids. It is this class of dysenterics to whom the operation is best adapted. I do not look upon it as a last resort at all, but as an entirely justifiable procedure for its palliative effects alone, as well as offering by far the best prospect of recovery. Major Arthur, the surgeon at the Home, uses two operations:

1. *Appendicostomy.*—The ordinary incision for reaching the appendix is made and the appendix is brought out and carefully examined; if it is inflamed, or not perfectly patulous, it should be removed and the operation of cecostomy done. It may be necessary, in order to determine positively whether the appendix is patulous throughout, to cut off the extreme tip and pass a small bougie-à-boule into the cecum, care being taken to avoid soiling the wound when the bougie is withdrawn. If the appendix is found to be in good condition, it is partly brought out at the lower end of the incision without disturbing the meso-appendix, about an inch and a half being left within the abdomen, and that part which is to be in contact with the abdominal wall lightly scraped to expedite adhesions. It is then stitched at three or four points to the skin, the stitches not encroaching on the lumen of the appendix. The incision is then closed layer by layer down to the point of exit of the appendix, and a simple dry dressing applied. At the end of forty-eight hours sufficient adhesion has taken place to prevent leakage between the appendix and the abdominal wall. The extruding part of the appendix is cut off flush with the skin (no anesthetic being necessary); a closely fitting rubber catheter is introduced, and irrigations begun.

FIG. 555.—SELF-IRRIGATION IN CHRONIC TROPICAL DYSENTERY AFTER APPENDICOSTOMY (Major Arthur, Soldiers' Home, Washington).

Some operators remove the entire appendix at the primary operation, bringing the cecum close to the wound and securing it there. This procedure loses all the advantages of the use of the appendix and calls for a perfectly useless search, as it would save time and trouble to make an opening into the cecum at once.

2. *Valvular Cecostomy.*—When for any reason the appendix is not available,—generally because it is not easily found, or because it is not in suitable condition for use,—the cecum should be brought up, a point in one of the muscular bands selected, and a valvular opening made on

the principle of the Stamm-Kader method of gastrostomy. (See Vol. III, p. 941.) Two purse-string sutures are made to surround the point selected, a very small opening is made, through which a snugly fitting catheter is pushed into the cecum for several inches. The catheter is stitched with very fine stitches to the edges of the opening; first the inner and then the outer purse-string is drawn taut and tied securely, thus raising up enough tissue around the tube to obtain a firm bearing surface. The ends of these sutures are secured to the abdominal wall to prevent the cecum falling back into the abdomen, and irrigations may be begun at once.

Of the two operations, the first is to be preferred. It secures a long, firm, bearing surface, minimizes the danger of leakage, and allows for subsequent closure of the fistula by a very trifling operation, if indeed the opening does not close of itself. The danger of ventral hernia is less than where cecostomy is done. This use of the appendix may also be applicable to other conditions than the one under consideration and deserves more notice than it has received.

The improvement after operation is most gratifying; the patient is soon able to extend his diet so as to include almost any ordinary food; the numerous scanty stools are replaced by one sufficient and painless evacuation at the time of the irrigation, so that the patient can go about without constant apprehension and annoyance. The weight and strength increase. A final cure is much more likely to occur than under any other treatment, and, at the worst, the pleasure of living is more or less restored to the sufferers. The small fistulous openings are not offensive to others, and the irrigations and dressings can easily be managed by the patients for themselves.

There are certain cases of chronic amebic dysentery which proceed slowly but inevitably to a fatal termination without improvement. At the autopsy table it is seen that the lesions are of such extent that the entire gut is practically disintegrated. The pathologic process has at no time been very acute, but has involved so large an area as to prevent any attempt on the part of nature to repair damages. It is discrediting a valuable method of treatment to confine operation to such hopeless cases. Patients who show by their response to treatment by rest, diet, or medication, that their large intestines are not entirely crippled are the ones for which irrigation from cecum to outlet is most suitable.

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TROPICAL ABSCESS OF THE LIVER.

Tropical abscess of the liver is another manifestation of amebiasis, and is always found associated with amebic dysentery, active or latent. The qualifying word "tropical" is better justified in this complaint than in many others, for although the geographic distribution is in general the same as that of amebic dysentery, it is proportionately much rarer in temperate climates. Hepatic abscess, not amebic, due to pyemia or to the direct extension of a neighboring suppurative process, has of course no special climatic limits, and although its occurrence is favored by tropical conditions, it must be looked upon as a cosmopolitan disease.

Causes.—The amebic abscess is especially common in adult white males resident in the tropics. The natives, who, as is well known, possess a decided immunity to dysentery as compared with white men, are even more immune to abscess of the liver. White women and children are very subject to dysentery, but seldom have abscess. The causes, therefore, of this most serious tropical complaint are both predisposing and specific. The life of a white man in the tropics, as already mentioned, is such that torpor of the liver is, under the most favorable circumstances, hard to avoid. When to the effects of heat are added excessive proteid consumption, lack of exercise, and alcoholic indulgence, then congestion, enlargement, and perhaps structural change of the organ are to be expected. An overworked liver may be still further injured by the almost inevitable attacks of malarial fever. When conditions are thus ripe for bacterial or protozoan infection, an exposure to cold or a slight traumatism may excite the invasion. Alcoholism is considered by most authorities as strongly predisposing to abscess of the liver, but it seems probable that its importance as an etiologic factor has been exaggerated. It is one, and perhaps the most frequent, predisposing cause, but long series or cases occurring in temperate men have been reported. To all of these conditions—overeating, overdrinking, fatigue, exposure, etc.—white male residents are much more subject than their carefully protected women and children, or the indolent temperate natives. It is more than doubtful whether abscess ever occurs as a primary lesion of amebiasis; in all cases dysentery is present or has previously existed. Where no dysenteric symptoms are found and no history of an antecedent attack can be elicited, the insidious character of intestinal amebiasis must be borne in mind. Patients often have the dysentery in such mild chronic form that it does not attract their attention enough to lead them to seek medical aid, the occasional looseness of the bowels being considered "diarrhea," which is too common an occurrence in the tropics to provoke a second thought unless unusually profuse or painful.

The parasites do not differ from those found in the bowel walls and voided with the stools in dysentery. They exist in the contents of the abscesses or in the partially disintegrated liver tissue immediately surrounding them, being more numerous and more actively motile in the latter situation. In old abscesses that have run a chronic course amœbæ may be absent. Bacteria of various kinds may be associated with the

amœbæ or the pus may be entirely sterile in bacteria. Streptococci, staphylococci, proteus, colon bacillus, and bacilli closely resembling the organisms of typhoid fever, have all been found. Bacteria are seldom plentiful in amebic abscess. Kartulis,[1] who first found amœbæ in the liver, teaches that bacteria are always brought in with the parasites, but sometimes die out in long-standing abscesses, having less resistance than the animal organisms. Kruse and Pasquale[2] believe that bacteria are necessarily associated with the amœbæ in abscess production. Councilman and Lafleur,[2] on the other hand, found only amœbæ in small abscesses in their earliest stage, and teach that they alone are the initial active agents.

The recent work of Musgrave, in Manila, demonstrating the necessity of symbiosis in the artificial cultivation of amœbæ, is here very suggestive, and would rather indicate bacterial coöperation in all the lesions of amebiasis.

The infection of the liver from the intestinal lesions is doubtless most often by the blood-stream, as the organisms are found in the small vessels near the ulcers, and also have been detected in the portal vessels. It is very improbable that the invasion of the liver ever takes place through the lymphatics, for although amœbæ are seen in the lymph-spaces of the intestinal wall, the glands seldom contain them and are never distintegrated by them. Infection through peritoneal surfaces has been fairly well proved, amœbæ having been found in the exudate of a peritonitis involving the intestinal coils and the surface of the liver.

Morbid Anatomy.—In about three-fourths of amebic cases there is a single abscess, but taking all hepatic suppurations, however caused, the proportion of single to multiple abscess is more nearly equal. When there are several abscesses, one is usually larger and evidently of longer standing than the others.

The liver is pale or congested; it may be enlarged, or, when the abscess is excluded, not above the normal. Where the abscess is superficial, localized perihepatitis is found and adhesions readily take place, as, for instance, in the very common case of abscess of the dome of the liver, where the diaphragm may be tightly adherent to the organ. The smallest abscesses are exceedingly minute, to be measured only in millimeters; the largest may reach the diameter of 12 to 15 cm. The situation may be anywhere in the liver structure, but four-fifths of all are in the right lobe. Next to the dome, the under side of the liver near the hepatic flexure of the colon is a favorite site. Large single abscesses are more apt to be deep-seated, but when the lesions are multiple and of small size, they are generally superficial.

The shape of the abscesses varies with the duration of the disease, or, in other words, with the acuteness of the destructive process. The small and recent ones are simply necrotic areas and the contents are semi-fluid only. On section a little glairy fluid exudes, leaving a yellow-gray, spongy mass behind.[1] As the abscesses become larger and older, liquefaction of the contents becomes more marked. The walls are generally irregular, consisting of necrotic tissue gradually shading off into normal

liver structure. There is seldom much inflammatory reaction in the neighboring tissue and but little accumulation of leukocytes. A well-marked abscess wall is rare; only in old and very chronic abscesses is there found a connective-tissue layer, which, however, may be well organized and very tough. The pus from abscesses is usually very thick and viscid, yellow-brown or chocolate colored, with small clots of blood and translucent streaks of mucus-looking material. It may be tinged green from bile, and often contains quite large shreds of partly disintegrated hepatic tissue. Microscopically it contains granular detritus and fragmented cells, leukocytes, red blood-cells, either scantily or in great abundance. The comparative absence of leukocytes is, according to Lafleur,[4] very characteristic of amebic abscess. Amœbæ are present in the pus in a considerable proportion of cases. The organisms are often absent from old chronic abscesses, but are plentiful in the small recent ones. Even when amœbæ are not found in the pus they may still exist in the partially necrosed surrounding tissues, and are indeed more active when so found. Bacteria, if present at all, are scarce, unless there is mixed infection, as, for instance, in abscesses adjacent to the flexure of the colon, where an amebic infection is apt to be followed by a secondary invasion of pyogenic bacteria.

The great irregularity of the periphery of the abscesses is due to the fact that the interlobular areas are more easily disintegrated than are the periportal areas, "which persist until they are detached from the wall by the confluence of the foci of interlobular necrosis."[3]

Councilmen and Lafleur also recognized in amebiasis of the liver a wide-spread cell necrosis around the central veins of the lobules, generally most marked in the neighborhood of the abscess, but not confined to such parts. These foci do not contain amœbæ and may be explained by the action of some soluble toxin produced by the parasites, while the disintegration and liquefaction constituting the abscess are due to the direct action of the living amœbæ upon the tissue previously rendered necrotic.

Involvement of the lower lobe of the right lung in the abscess formation is not an uncommon occurrence. It occurs in abscess of the dome, and is a direct extension through the diaphragm, which is adherent to the lower surface of the lung and to the liver.

There may be an opening in the diaphragm or the two abscess cavities may show no visible channel of communication through the thickened partition. The pulmonary abscess is deep-seated and central. The neighboring lung tissue is consolidated, and the cavity may be full of pus, or, if there has been perforation into a large bronchus, it will be kept fairly empty by coughing and expectoration. The pus is similar to that in the liver abscess, and may, of course, contain living amœbæ.

Symptoms.—The patient is either a sufferer from dysentery or will give a history of having had a flux at some time—it may be weeks or months—previously. Generally there is existing dysentery, more or less severe, for the occurrence of the liver infection is apparently in no way dependent upon the severity of the intestinal disease. Abscess seldom develops before the dysentery has existed six or seven weeks, but it may then

occur at any time, when the dysentery has been going on for many months, often when the patient is steadily improving or even considered as cured.

Pain in the hepatic region is an early symptom, sometimes dull and steady (when it is too much like the aching or dragging of the commonly torpid and engorged liver of tropical residents to attract much attention), or sharp and tearing in character. A characteristic site of pain is in the right shoulder, reflected from the hepatic terminals of the right phrenic nerve through the fourth cervical to the brachial and cervical plexuses. It may radiate, therefore, over the neck, the scapular or clavicular regions, or down the arm, and is constant or intermittent, dull or acute. Pain over the liver is felt in the epigastrium, the right hypochondrium, or in the lower axilla. When the pain is severe the patient assumes a characteristic decubitus, lying upon the right side of the back with the body curved to the right and the right limb drawn up. Pain is, on the whole, almost a universal symptom, but it is quite possible for a liver abscess to attain a great size without pain enough to call serious attention to the part. Godlee[5] speaks of a young officer, suspected of having an abscess, going through a winter's hunting and returning to show himself well, as he thought, although the abscess was almost "pointing" at the epigastrium. Some of the cases where abscess is first diagnosticated after years of comparatively good health have intervened since the patients returned from the tropics, and since the last dysenteric symptoms, must be of this nature. Certainly it is often impossible even to estimate approximately the length of time such abscesses have been developing.

Fever is also a constant symptom, although it may not be severe; very rarely it may be entirely absent. A high average temperature generally indicates bacterial infection, as purely amebic abscesses generally do not give a high elevation. The fever varies with the acuteness of the disease and with its duration. In acute and sthenic cases the temperature is continuously high for days and then becomes remittent in the morning, as in suppurative conditions generally. In slow and chronic abscess formation the fever is slight, with periods of several days of apyrexia and a very gradual development of a low-grade remittent curve. Irregular fluctuations in the fever charts are common enough in any type of abscess. An initial chill is significant when it occurs, but is very often absent in amebic abscess. Indefinite chilly sensations, however, may occur with daily regularity, preceding the evening rise of the temperature, and closely simulating a quotidian malarial fever. Sweating is a usual symptom, occurring irregularly by day and night, and in advanced cases it is very profuse, drenching the clothing and bedding. It is a valuable diagnostic sign in patients seen in temperate climates, but does not have much significance in the tropics, where almost all bed-patients—to say nothing of doctors and nurses—spend half their time in a drenched condition.

The pulse and respiration are both accelerated, the latter being markedly so when involvement of the lung has taken place. The skin is sallow and slightly jaundiced; the tongue foul, and there are various gastro-intestinal derangements. The appetite is lost from the first, while thirst

is increased. Nausea and vomiting are not common symptoms, and indicate either an abscess on the under surface of the liver near the stomach, or else they occur where the lung is involved, and fits of coughing produce vomiting. A return of the dysenteric stools is quite common, if not already present. However, the bowels may be constipated, the stools being pale colored from absence of bile.

Wasting and loss of strength progress slowly or rapidly, according as the case is acute or chronic, there being the greatest difference between individual cases in this respect. In one case the symptoms are serious from the first, the patient rapidly going down-hill; in another the change for the worse is so slow that the true condition is overlooked or mistaken for something else.

The physical signs of abscess of the liver are unfortunately generally obscure at the time when it is most important to make a diagnosis. Also the diagnosis is more difficult when the lesion is in its commonest situation —deep-seated in the right lobe.

Percussion shows enlargement of the liver dullness, relatively early, downward and to the center when the abscess is in the left lobe; downward, when in the anterior and lower part of the right lobe. When the middle of the right lobe is affected and the abscess is deep-seated, or when the lesion is in the dome adjacent to the diaphragm, the dullness extends upward.

Inspection reveals nothing unless the abscess is very large, in which case there may be fullness of the lower thoracic region, or obliteration of the right costal margin or of the epigastric hollow. Rhoads also notes engorgement of the superficial veins over the liver as an early symptom. Measurements may occasionally, although rarely, show the right side of the thorax to be larger than the left.

On palpation the edge of the liver may sometimes be felt. There is sensitiveness to pressure through the abdominal walls, or sometimes over the lower ribs and cartilages. With superficial abscesses there is peritonitis, and the slightest pressure is extremely painful. Also the right rectus muscle is rigid—a valuable sign, as it occurs before peritonitis is otherwise evidenced. Fluctuation is felt only exceptionally, and in large abscesses pointing anteriorly.

When the lung is involved, the fact is manifested much more by general symptoms, pain, hacking cough, and purulent expectoration, if the abscess ruptures in that direction, than by any very definite physical signs. The expansion of the right side is diminished; the percussion sound is dull from extension of liver dullness, the breathing over the lower lung is very faint or inaudible; friction sounds may be heard. After rupture there is bronchial breathing and coarse and bubbling râles with sudden diminution in the liver dullness, or possibly all the signs of a lung cavity are present.

Diagnosis and Course of the Disease.—The diagnosis of liver abscess is an easy matter only when the symptoms are acute and well-marked, or when the abscess is in certain locations. Very often it is extremely difficult. A proper history of the case is of the utmost

importance, and an antecedent dysentery, even if long past, is very significant; the actual presence of amœbæ in the stools still more so. In the absence of physical signs especially indicating liver disease, a wrong diagnosis of certain common infections is very apt to be entertained, such, for instance, as sepsis, tuberculosis, or chronic malarial infection. Especially common is this last error, and excusably so in many instances, for not only are the general symptoms strikingly like those of an irregular malarial fever, but liver abscess and dysentery are very often coexistent with chronic malaria. Unless, therefore, the signs of liver abscess have been unusually clear, we will nearly always find that the patients have been thoroughly cinchonized for the relief of their obstinate "malaria." When the presence of a collection of pus in the liver is made out, the differential diagnosis from suppurating hydatid or non-amebic abscess is difficult, or perhaps impossible, without surgical exploration. An empyema may also be hard to differentiate. If all the symptoms are clear as to liver abscess, an attempt should be made to determine its location from general signs, and occasionally much useless probing of the organ may be thus avoided. Boinet[6] gives the following as valuable localizing symptoms:

1. Deep central abscess—the pains are vague, deep, and increased by shaking the liver; the change in the shape of the organ, as evinced by dullness, is slight; the patient moves himself without difficulty; there are seldom any serious gastric symptoms.

2. Superficial abscess—peritonitis; the pain is acute and spreading; the diaphragm is elevated (if in the right lobe); there is possible displacement of the heart or dyspnea (left lobe); there is fixation of the abdominal wall and friction sounds.

3. Abscess of concave surface of liver—there are pain in the lumbar region, vomiting and icterus.

Urinalysis gives little information of value. Urea is diminished and slight traces of albumin are often present.

Leukocytosis with special increase of the polymorphonuclears is a valuable and early diagnostic sign, taken in connection with other symptoms, but it must not be forgotten that unmixed amebic abscess does not provoke very intense inflammatory reaction with high leukocytosis. As early diagnosis is all-important and is often difficult, blood examination should never be omitted, and even a moderate leukocytosis, if there is increase of polymorphonuclears, is regarded as a significant early symptom. A moderate but progressive anemia is also to be expected. Eosinophilia is generally found, but has little diagnostic value, being common to all diseases due to animal parasites.

Radiography is of little value as an early means of diagnosis. In far-advanced cases changes in the liver contour and fixation of the diaphragm may be disclosed, or a perihepatic collection of pus may be differentiated.

Diagnosis by exploratory puncture or by laparotomy will be considered under the head of treatment.

On the whole, the diagnosis of early amebic abscess short of surgical

exploration must be made from a careful consideration of many ill-defined symptoms, no one of which singly is of much importance. When any of the classic signs are very well marked, the disease will generally be found well advanced or there is mixed infection. With a history of dysentery, a combination of many of the symptoms already described, even when too slight to have brought the patient to bed, will justify more radical means of exploration.

Prognosis.—Liver abscess untreated surgically is a very fatal disease. Encystment of a small abscess is perhaps possible, but certainly extremely rare, and rupture, however favorable in direction, is seldom followed by recovery. In about one-fourth of all cases life will last long enough for rupture to occur. The most usual direction is into the lung or pleural sac; in the first case a septic pneumonia is to be feared, in the latter an empyema. Very exceptionally evacuation through the lung is followed by recovery, but more often the lung abscess will repeatedly fill and be discharged through the air-passages until the patient dies exhausted. Evacuation into the colon, a very rare occurrence, gives usually only temporary relief, with final death from sepsis. Rupture externally through the abdominal walls, rare at best, is apt to find the patient in such an exhausted state as to offer but little hope. Multiple abscess is always unfavorable.

Treatment.—Surgical evacuation and drainage of liver abscess are practically the only means of treatment giving any hope of a cure. Whether the patient will finally completely recover his health depends, of course, not only upon the success of the operation, but also upon the outcome of the intestinal disease. As far as the hepatic lesion is concerned prompt surgical interference, properly undertaken, is very satisfactory, the mortality in cases of solitary abscess being now not over 14 per cent., while some multiple abscesses are successfully treated. Failure in cases where the lesion is single is generally due to delay while awaiting the disease to declare its presence by unmistakable symptoms. So important is early diagnosis and immediate operation, that where a strong suspicion of liver abscess exists the tendency now is to perform unhesitatingly an exploratory laparotomy, and locate the lesion by direct inspection, palpation, or puncture of the organ. Surgeons who are unwilling to use such radical measures of diagnosis—and they are perhaps still in the majority—depend upon exploratory aspiration with a large-sized needle. Sometimes the location of the abscess is easily made out by such exploration, but very often repeated punctures in all directions give no result; especially is this likely to be the case in beginning abscesses, which escape puncture on account of their small size. Besides, these early lesions are rather areas of necrosis going on to liquefaction than true abscesses, and no pus will be obtained even when the needle has entered the right spot, as the contents are too thick to run through the aspirating needle, or the lumen may be blocked by a fragment of tissue. The procedure cannot be considered altogether free from danger, although, as a rule, no harm results from it. Repeated punctures are sometimes followed by considerable shock, and there is danger of conveying infected

matter to the pleural or peritoneal cavities in withdrawing the needle. When aspiration has been decided upon, the patient must be prepared and all things be made ready for free evacuation and drainage in case the abscess is located. Robinson[7] determined from experiment on the cadaver that the most promising spot for puncture with the exploring needle is in the mid-axillary line, through the eighth interspace, as about one-half of the liver may be searched in all directions thence, including the part that is most likely to be affected. Additional punctures may be required in the right and left lobes, made near the median line of the abdomen below the free border of the ribs. Rhoads[8] recommends systematic examination of the entire organ through the curvilinear incision below the margin of the ribs, with the center over the gall-bladder. The incision is made large enough to admit the whole hand, and the palpation is begun on the under surface of the liver, starting at the right side, inserting the fingers to the posterior limits, then withdrawing the hand, and making the examination of the upper surface from right to left. The size of the liver and its relations to external landmarks are thus determined, adhesions and irregularities of contour are noted, and if suppuration has begun, it will be evinced to the palpating finger by a sense of "resistant tense bogginess" requiring some experience to recognize. When an abscess is located, further exploration is nevertheless necessary, for there may be another.

The location of the abscess determines the route by which it must be evacuated, which may be either infracostally through the abdominal wall, or through the chest wall. When the abscess is in the left lobe, in the lobulus Spigelii, the lobulus quadratus, the under or upper surface of the right lobe, but near the margin, Rhoads uses his exploratory incision, enlarging it if necessary so as to bring a part of the cut directly over the point of the liver to be attacked. In abscesses of the upper part of the right lobe posterior or deep-seated, he closes the laparotomy wound and proceeds through the thoracic wall.

When the abscess has been located by aspiration, the needle should be left *in situ* as a guide during the operation.

In cases suitable for infracostal operation the belly wall is opened at the point indicated, which is usually a fingerbreadth below the costal margin and external to the rectus muscle, although it may possibly be in the median line of the abdomen. If adhesions exist, protecting the peritoneal cavity, the abscess is opened at once; if there be no adhesions, either a delay of forty-eight hours is allowed for their formation, or, better still, the area of liver surface to be incised must be walled off from the surrounding structures by sterile gauze before proceeding further. The capsule of the liver is divided by the knife, and when the abscess is deep-seated the rest of the way must be made with the finger, or by boring through the tissue with a pair of long closed hemostatic forceps. The fear of hemorrhage, which is quite profuse when the liver is incised, has led foreign surgeons to recommend the use of the cautery for opening the abscess, but as bleeding can be controlled by packing, and usually promptly ceases when the evacuation is complete and the con-

gestion of the organ relieved, this method has not found favor with American surgeons. The opening into the abscess cavity should be 4 or 5 cm. long, and as soon as the pus appears it must be rapidly sponged away to avoid soiling the surrounding gauze packing. After evacuation the cavity is explored with the finger, remembering that a so-called secondary abscess is often an immediate extension of the first, separated from it by necrotic tissue that may be broken down by the finger. Curetment is not to be advised. The interior of the cavity is mopped dry and drained with gauze strips and a stiff rubber tube, as gauze alone will not drain away the thick liver pus.

In many cases of liver abscess the route through the thoracic wall is to be preferred, and indeed presents many advantages. As usually located, the pus is reached more directly, there is little danger of peritoneal infection, and drainage is naturally favored with the patient in the most comfortable position. A portion of one or more ribs must be excised or else good drainage will not be obtained. The cut through an intercostal space is not sufficient. Either the wound will contract and compress the drainage-tube or the liver, emptied of its weight of pus, will change its position so that the opening in the liver is no longer in direct line with the external wound and the tube slips out, or becomes "kinked" so that its lumen is occluded. The resections are made at or behind the axillary line, comprising portions of the eighth, the ninth, or of both ribs as may be indicated, to the extent of 8 or 9 cm.

In cases where the pleural walls are agglutinated and the liver is adherent to the diaphragm, the abscess is entered boldly through all structures, but if unaffected, the pleural sac should by all means be kept uninjured whenever possible. The parietal and diaphragmatic layers may be reflected upward out of the way, or if accidentally or unavoidably cut through, the wound in the sac should be united by sutures. The diaphragm is divided, preferably in the direction of its fibers, and when no adhesions exist, gauze must be packed all around between the diaphragm and the upper surface of the liver. The liver is opened as before described, and as low down as circumstances will permit, because the organ relieved of its load of pus is apt to shift its position upward. Gauze drains and a large rubber tube are used to drain the cavity and are brought out at the posterior angle of the external wound, part of which, after securing satisfactory drainage, may be closed. The after-treatment consists of voluminous dressings frequently renewed for the first few days, when the discharges are usually profuse and thick; later on, when they diminish in quantity and become thin, sanious, and sometimes bile-stained, irrigations with warm salt solution are indicated. About the sixth day the drainage-tubes and gauze may safely be removed, and are then to be renewed daily and irrigation practised until all discharge ceases and the cavity fills up. Anodynes and stimulants are used as required after operation, and careful dietary and nursing kept up until recovery is complete.

A method advocated by Manson[9] of evacuating liver abscesses should here be mentioned. The pus having been located by the aspirator, the

skin is incised slightly and a trocar with its cannula $\frac{3}{8}$ inch in diameter is plunged into the cavity. A stout rubber tube one-half inch in diameter and six inches long is stretched to twice its length over a steel stilet, and in this condition can be made to pass through the lumen of the cannula. The trocar is withdrawn, allowing enough pus to escape to relieve tension, and the stretched tube is inserted until the deepest wall of the abscess is reached. Removing the cannula by sliding it over the tube, the distal end of the stilet is disengaged and the tube allowed to slacken back into the puncture wound, while the proximal end is held firmly against the bottom of the pus cavity. Manson uses two steel buttons as "points d'appui" for the ends of the stilet, lashing them firmly within the lumen of the tube at each end, the buttons having a hollow shank to receive the point of the stilet. The same object may be attained by using a blunt or ball-tipped rod and simply tying the ends of the tube firmly. This operation has its uses, no doubt. It has no terrors for the most timid surgeon, and in the absence of hospital advantages, trained assistance and nursing, or in the hands of a general practitioner unprepared for abdominal surgery, it is yet to be commended. In the light, however, of the excellent results of early and radical measures in this serious disease it is not likely that a well-equipped surgeon will be contented with anything less than complete exploration and perfect drainage. Without adhesions, by this method there must be danger of infecting the peritoneal cavity when the cannula is withdrawn; and with an adherent liver, free incision and drainage require no more expertness than does the opening of any superficial abscess.

The results of operation in liver abscesses will undoubtedly become even better than at present if early evacuation and drainage are more generally practised.

Deaths after operation are now ordinarily due to the enfeebled state of the patients, who succumb to exhaustion, or who cannot stand the shock of operation. Exceptionally death occurs from hemorrhage from the cavity where a large vessel has been opened in the abscess formation. Several cases in which the vena cava inferior was involved have been reported.[10]

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FILARIASIS.

The commonest animal parasites of man in the tropics, next to the malarial organisms, belong to the genus *Filaria*, which is widely distributed, being found in the tropical and subtropical regions of Asia, Africa, North and South America, Australia, the Pacific Islands as far north as Japan, in Madagascar, the West Indies, and elsewhere. They have often been observed in the southern United States and are fairly common in our tropical possessions—Porto Rico, the Philippines, and Panama. In some places, as, for instance, Samoa, a third or a half of the population is affected.

The filariæ (fam. Filariidæ),[1,2] constituting an extensive group of nematodes, are generally long and slender, the males being much smaller than the females. They are filiform worms of generally uniform size throughout their length, perhaps tapering gradually at their extremities. The males have recurved or spiral tails, with sometimes lateral wing-like appendages, and several papillæ before and behind the anus. In the female the vulval opening is near the mouth. There are numerous species of filariæ parasitic in mammals, birds, reptiles, fish, crustaceans, insects, etc. In man fifteen or sixteen species have been described, some of which occur also in other mammals. Of the filariæ of man some inhabit the blood-vessels, the lymphatics, and the serous cavities of their host, others the connective tissue. Four or five varieties are found as adults in the lymphatic vessels and elsewhere, while their embryos enter the circulating blood in enormous numbers. Another group is composed of those worms which live in the connective tissue and apparently do not enter the lymph or blood-currents in any form. The only one of the blood parasites of surgical importance is Filaria Bancrofti, the embryonal form of which is known as F. nocturna, and the diseases due to its presence are generally understood when the term "filariasis" is used.

The life-history of the F. Bancrofti and the surgical diseases due to its presence have been treated of already in this work (see Surgery of the Lymphatics), so that the subject will receive but brief comment in this chapter. The embryo filariæ, although circulating in the blood by millions, do not apparently cause pathologic conditions in man, but the parent worms, residing somewhere in the lymphatic system, are the origin of various diseases, in a certain small proportion of the whole number affected. These pathologic conditions are sometimes caused by mechanical obstruction of the lymphatic circulation only, with or without rupture of a vessel, as, for instance, chylous ascites, lymph varix, varicose groin glands, lymph scrotum, chylocele, etc. The most serious results, however, are also due to secondary invasion of the parts where there is lymph stasis by pyogenic organisms. In this way is to be explained the occurrence of orchitis, lymphangitis, abscess, and occasionally a general infection.

A good example of this is seen in a case reported by Opie,[3] which was admitted to hospital with diagnosis of strangulated hernia and peritonitis. The tumor in the groin proved to be a lymph varix, and when a lapa-

rotomy was done to determine the cause of the peritonitis, it was found that, besides the large mass in the groin, there was great dilatation of the abdominal and pelvic lymphatics. The case ended fatally, and at autopsy a parent filaria was found in a large lymph-vessel, as well as some embryos in a branch of the hepatic vein. The secondary infection was due to Diplococcus lanceolatus, which had caused a fibropurulent peritonitis. In endemic elephantiasis we must also recognize two necessary factors—a general filarial lymph obstruction of the part, and an often repeated inflammation, each attack leaving its addition to the enormously thickened skin. The infective organism here is most probably the Streptococcus pyogenes, and the attacks of so-called "elephantoid fever" are doubtless nothing less than erysipelas characterized by rigors, high temperature, and severe constitutional symptoms generally. Indeed, some European writers insist upon this factor, while denying that *filarial* obstruction is necessary.

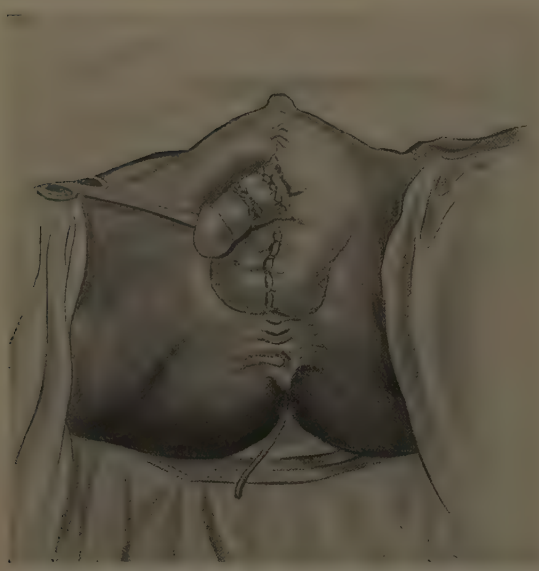

FIG. 556.—OPERATION FOR ELEPHANTIASIS OF SCROTUM (Charles).
Wound covered in by flaps from thighs. Base of penis also closed over by the same; small reflection of healthy lining of prepuce from cervix.

Surgical Treatment of Elephantiasis of the Scrotum.—The ordinary operation has already been described (Vol. II, p. 599), but of late years Professor Charles, of Calcutta, has used a method differing from this in many respects, in which he has attained remarkable success in several hundred cases.[4]

Charles has abandoned the tourniquet entirely, and proceeds at once with the incisions, picking up each vessel before cutting it, or immediately afterward. He first liberates the penis, and then makes an incision around the neck of the tumor from the median line in front of the anus to about the external abdominal ring. The exact position varies somewhat according to the state of the skin, as it is desirable to save as much healthy skin as possible for better closure of the wound, but essential to avoid diseased tissue. A similar procedure on the opposite side makes a U-shaped incision in which all of the largest vessels can be dealt with before ablating the tumor. The incision is deepened with scalpel and finger, each vessel being seized with pressure forceps. The vessels from which hemorrhage is to be feared are: above, the superior (superficial) external

pudic and the inferior (deep) external pudic; at the sides of the perineum, muscular branches of the sciatic; at the back of the tumor, running forward, are the superficial perineal vessels, always the largest of the tumor. These once caught there is little to be feared from the remaining vessels. The dorsal vein of the penis may be very large, but it should never be wounded when the penis is shelled out; the artery of the frenum is troublesome, however, and may require a ligature. Charles works from behind forward so as to secure the large perineal vessels first.

The ends of the U-shaped incision and the upper end of the vertical cut through which the penis has been enucleated are now united and all vessels are seized and clamped; the testicles are enucleated through vertical incisions as already described (there may be some hemorrhage from the cremasteric branches) and the removal of the tumor is completed without trouble. No ligatures are used, but hemostasis is secured by twisting each vessel held by a pressure forceps, applying a second clamp to the twisted vessel and leaving it on for several minutes. As forty or more vessels sometimes require attention, the absence of ligatures is an immense advantage in the healing process of the extensive wound of operation. The tumor having been removed, the penis and testes cleaned from all diseased tissues, hydroceles and hernias properly dealt with, the closure of the wound is undertaken, which is a matter requiring much skill and care to produce a perfect result.

The skin to one side of the wound is drawn forward, pulling taut the fascia of Colles with which it is lined. A cut about half an inch long is made through the fascia and the finger inserted and moved up and down, working gradually outward, thus freeing the skin from the fascia lata over the origins of the adductors and the gracilis muscle; any portion of Colles' fascia obstructing the free sliding of the flap may be snipped with blunt-pointed scissors. By practice the amount of covering necessary to reach the median line of the large wound of operation is determined. The procedure having been repeated on the other side of the wound so that the skin flaps meet without tension, a testicle is placed under each flap. There should be no bleeding from the cord or from the spot where the tunica has been cut, and sometimes just here a small vessel may require a ligature. When the cord is very long, it will be necessary to make several folds in its length, using a few stitches. After each testicle has been tucked away in its pocket the flaps are sutured in the median line, up to the penis. The wound in front of the penis is closed in a similar manner. The edges of the flaps must now be stitched around the body of the penis by using half-a-dozen very fine sutures through the flaps and the tunica albuginea itself, avoiding the dorsal vessels and not entering the erectile tissue. Charles from long practice has been able to dispense with all drainage, but as in addition to the large wound of operation an extensive absorbent area has been opened up in the flap-making, surgeons not familiar with this operation might wisely use drainage from the lower end of the wound.

If any portion of the prepuce has been kept, it may be used as part of the covering of the denuded penis, but in case of doubt as to its perfect

freedom from degeneration the entire prepuce had better be sacrificed. The penis may be skin grafted by the Thiersch method at the time of operation, or this may be postponed until a later dressing.

A strip of oiled silk or gutta-percha tissue is put around the penis and the organ is carefully bandaged with gauze, firmly near the gland, and more loosely around the root, to prevent swelling. The pubic and perineal dressings consist of proper lengths of gauze allowed to fall and arrange themselves from above downward on either side of the penis; the inner edges of which folds must be stitched evenly and firmly to the bandage of the penis. A double spica must be now put on with the utmost care, and the whole dressing be kept firm and without danger of shifting by the use of safety-pins and needle and thread. Charles considers this so important a point that he always does the dressing and bandaging himself. The dressings are renewed on the fifth and the tenth days, and must be done with equal care as at first. Skin grafting of the penis, if not done at the time of operation, may be postponed as long as to the latter date.

This operation, formerly formidable from the danger of hemorrhage and sepsis, is under modern conditions a safe and satisfactory one, the mortality having dropped from 19 per cent. to 1 per cent. or less. Of course, the removal of such tumors before they have reached an enormous size is to be encouraged among the population afflicted with elephantiasis, and it is likely that as the success of modern surgery becomes better known, tumors weighing fifty or a hundred pounds will be no longer reported. After removal the position of the testicles against the perineum is for a time somewhat inconvenient, but a sort of new scrotum gradually forms. Virility is generally preserved and the recurrence of the disease after operation is becoming more and more rare.

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GUINEA-WORM DISEASE OR DRACONTIASIS.

One of the oldest known tropical diseases is due to the presence of the Guinea or Medina worm, a member of the Filariidæ (F. medinensis or Dracunculus medinensis),[1] the adult female of which inhabits the superficial connective tissue, and is delivered of her progeny through the skin. The disease was known to the Greek, Roman, and Arabic physicians, and is even believed to be alluded to in the Papyrus Ebers, over three thousand years old, and in the Book of Numbers, Chapter XXI, where the Israelites are said to have suffered from a plague of "fiery serpents" while on the shores of the Red Sea.

The parasite is found in more or less circumscribed areas in Asia and Africa, where sometimes it is a true local scourge afflicting half the population. It was imported into America with negro slaves, and although

it never made great headway, a few small centers of disease persist in Brazil and the Dutch West Indies. The worm has many local names, but in English it is usually spoken of as Guinea or Medina worm, or called by its old Roman name of Dracunculus.

In spite of its ancient history, the life-history of the Dracunculus is not yet entirely clear. The adult female is alone concerned in the painful pathologic process that its tedious parturition set up in the luckless human host. It is a yellow-white round worm, very slender, about 75 cm. long, and only averaging a little over a millimeter in breadth, tapering gradually toward the caudal end. The outer skin is tough and very elastic, playing, indeed, the expulsive part in parturition. The head is blunt, having an oral orifice and a number of papillæ supposed to be sense-organs; the tail end is hooked. With the exception of a narrow intestinal tube, the body of the worm is entirely taken up with the uterus, containing several millions of flat worm-like embryos. Escaping from the mother, these embryos are aquatic for a period, living certainly several days in dirty water or soft mud. They then become parasitic in the ventral cavity of a certain fresh-water crustacean (Cyclops quadricornis)[2]; go through several changes, are motile at first, but after a few weeks gradually become motionless and encysted. The history of the interval between the larval stage in cyclops and the adult stage in the human host is still somewhat obscure. The interval is a long one, for it has been possible to determine very accurately that the time elapsing from the only possible infection in an endemic center to the appearance of the pregnant female in the peripheral connective tissue is about ten to twelve months. Undoubtedly the process is about as follows: A number of cyclops containing embryo Dracunculus are swallowed in drinking-water; in the stomach the bodies of the crustaceans are disintegrated and the larvæ escape. A recent observation of Leiper[3] shows that *in vitro* the addition of very dilute HCl to the infected cyclops kills the animals and awakens the encysted larvæ of Dracunculus to renewed activity by which they manage to escape from the body of cyclops. This experiment is strongly suggestive of what goes on in the human stomach when contaminated water is swallowed. The same observer[4] fed a monkey with bananas containing cyclops in which the larvæ of Dracunculus were apparently mature. Six months later the animal was killed, and on autopsy three female and two male filariæ were found in the connective tissue. The females were immature and unimpregnated, which fact seems to dispose of the theory that sexual congress takes place in the human intestine, the female alone penetrating the connective tissue. As the young females had already found their way to the extremities, it seemed probable that fertilization and parturition take place in the same location and that the large pregnant female does not, as has been supposed, make her way without injury to the tissues through which she passes to the periphery. Certainly at first sight the adult female seems to display a most marvelous knowledge of the best place to establish herself, so that the coming progeny may most certainly reach their necessary watery home, for we find that in 75 per cent. of all cases the worm presents

itself in the lower extremity, generally below the knee. This selection in bare-legged negroes and Indian coolies is, of course, the best possible. Harrington[5] observed that when the disease appeared in the "bhistis" or water-carriers of India, a large proportion of the worms showed on the back and loins, where the wet water-sack had been carried day after day. Instead of attributing such unerring knowledge of the habits of its host as would lead the worm to travel to the very point in the body most likely to be in contact with water, we must now admit that the embryos reach their destination early, and that the female develops *in situ*. The theory, not yet discarded, that infection takes place from water containing larval worms which enter the skin directly is strengthened by the well-known behavior of the larvæ of Strongyloides and Anchylostomum, where entrance through the skin has been thoroughly demonstrated, but in the light of Leiper's experiments it seems proved that only in the body of cyclops and through the stomach can dracontiasis be acquired.

Symptoms.—The first symptom of the presence of the worm is an inflammatory swelling on the leg, foot, arm, back, groin, etc., as the case may be. There are seldom many marked preliminary sensations, although itching or burning of the part, with sometimes an urticaria-like eruption, attributed to toxins generated by the parasite, have been noticed. Just as in the case of other animal parasites, blood examination may show eosinophilia. As the tumor develops pain becomes severe, the limb is crippled, and sometimes marked constitutional symptoms, such as fever, rigor, nausea, nervous irritability or possibly convulsions, occur. When the swelling has reached the size of a nut or of an egg the epidermis is raised at some point into a small vesicle filled with fluid, at first clear and then turbid. After a few days the vesicle bursts, exposing a small area of denuded corium which is perforated by a central channel, through which after a day or so the head of the worm will be protruded. When the neighboring parts are now douched with cold water, the worm is seen to eject a quantity of turbid fluid swarming with embryos. Occasionally the first opening closes and a second appears at some neighboring point. Sometimes, from external infection, the whole bed of the parasite will constitute an abscess cavity, from which finally the entire animal is discharged; but usually the process of parturition is aseptic as long as the worm is allowed her own time undisturbed. Emptying several inches of the uterine canal little by little every day, she completes delivery, the uterus itself being gradually forced out through the oral orifice of the worm, and through the canal in the host's skin. After each portion has been emptied it shrivels and dries, to be followed by the protrusion of a new section, which also ruptures and discharges itself. The whole process takes two weeks or more, after which the worm may be drawn out from its bed and the disease is over.

If the worm is ruptured in the tissues by forcible attempts at extraction, the uterine contents usually have a violently irritative effect on the tissues, causing inflammation and swelling, with liability to subsequent infection by pyogenic organisms. The results may be quite serious, as sloughing,

necrosis of bone, purulent synovitis, and general sepsis have all been recorded.

The **treatment** is either to allow the worm to empty itself, rolling up the extruded part every day on a bit of wood and protecting the part by clean wet dressings, or else the parasite may be cut down upon and carefully removed intact. The location may be such that the surgeon does not care to interfere, as, for instance, between the metatarsal bones or in the near neighborhood of a joint. Here the case may be left to nature, expediting delivery by frequent douching with water.[6]

The worm may be killed by injecting it with sublimate solution 1:1000, as recommended by Emily,[8] or with alcohol, as suggested by Foulkes,[7] and then it can usually be drawn from its bed without trouble. Removal at once by incision is generally to be preferred, saving much discomfort and time.

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MYCETOMA, OR MADURA FOOT.

Madura foot, fungus disease of India, or, more properly, mycetoma, is a localized infection due to several varieties of vegetable parasites, nearly always, though not invariably, attacking the foot. It is characterized by the development of a slowly growing inflammatory tumor, and the production of granules of different kinds, which consist of mycelial growths and cell detritus from the tissues of the patient, and which are given off through fistulous openings. The disease is incurable and in time disintegrates the member, rendering the patient a helpless cripple, but it is attended with little constitutional disturbance, and for a long time does not seriously affect the general nutrition.

Mycetoma is endemic in India, where it is widely distributed, although many places remain exempt. In recent years the disease has awakened more general interest, as it has been found in Africa, in Europe, and in both North and South America. Non-imported cases have been reported from several parts of the United States; one indigenous case in Italy and one in France.

Anglo-Indian physicians recognized the parasitic character of mycetoma fifty years ago, and H. Van Dyke Carter[1] gave us what is yet the most complete general treatise on the subject.

Causes.—After the discovery of actinomycosis the similarity of the two diseases was at once noted, and they were even declared to be

identical. The present view is that although the actinomyces may cause a clinical "fungus foot," mycetoma as usually described is due to several different though related plants. The study of the pathogenic higher bacteria and lower fungi, between which the dividing-line is very indefinite, is yet in its infancy, and is surrounded with many difficulties, so that their precise classification is beset with doubt and uncertainty. We are therefore not surprised to find that the specific cause or causes of mycetoma are far from being thoroughly understood.

Based on the color of the grains formed in and extruded from the tumors, three clinical varieties of mycetoma have long been described; they are the white or yellow variety, which is most common; the black variety; and lastly a red or pink kind, which is very rare. Vincent[2] succeeded

FIG. 557.—MADURA FOOT (from a specimen in the Army Medical Museum, Washington).

first in cultivating the fungus from a white mycetoma, and Wright[3] obtained from a case of the black variety a growth producing black sclerotia in old cultures. Very recently (1906) Emile Brumpt[4] has systematized our knowledge of the etiology of this interesting disease in a most satisfactory manner. From experiments on specimens from widely separated regions of the world, Brumpt so far recognizes eight different parasites capable of producing the clinical aspects of mycetoma. Six of these produce the "white" form and two the "black," and among the former he places the well-known ray fungus, here classified as a discomycete. (See Actinomycosis.) According to this author, the parasites and resulting tumors should be classified as follows:

Organism.	Disease.
1. Discomyces bovis (actinomyces).	Actinomycosis (*q. v.*).
2. Discomyces maduræ (Streptothrix maduræ).	Most common white mycetoma of India.
3. Aspergillus nidulans.	White mycetoma (unique case).
4. Aspergillus bouffardi, n. s. Brumpt.	Black mycetoma (unique case).
5. Madurella mycetomi (Streptothrix mycetomi, Laveran).	Most common black mycetoma.
6. Indiella mansoni, n. g., n. s. Brumpt.	White mycetoma (one specimen only, but very common in India).
7. Indiella raynieri, n. s. Brumpt.	White mycetoma (unique case, Paris).
8. Indiella somaliensis, n. s. Brumpt.	White mycetoma (found in Somaliland, but supposed to be common in India).

The last four fungi the author places provisionally among the mucedineæ, because the lack of knowledge as to their method of fructification does not entitle them to be ranked otherwise, but he believes that future research will prove these to be ascomycetes as well as the others.

The tumors produced by these parasites may not differ essentially among themselves in gross appearance or in symptomatology, but may be differentiated by the size, shape, and color of the grains, and still more surely by microscopic examination. For the production of the disease certain conditions, as yet unknown, must be necessary on the part of the patient and also of the plant, otherwise the disease, one would think, would be more wide-spread. Tropical temperature, moisture, and perhaps the geographic distribution of grasses, cereals, or other plants, on which possibly the fungi are saprophytic, are probably factors in maintaining the disease. Very many cases date from an injury to the foot, quite often a wound by a thorn, which must be almost a daily occurrence to a barefooted inhabitant of the tropics. One of the greatest differences between actinomycosis and the tropical foot disease is that the latter is, as far as we know, not inoculable to animals or man from the organism as found in the lesions. The inference is that a peculiarly resistant form of the fungus must be picked up in some way through a wound in the skin, a form capable of overcoming the natural defenses of living animal tissue and of growing indefinitely.

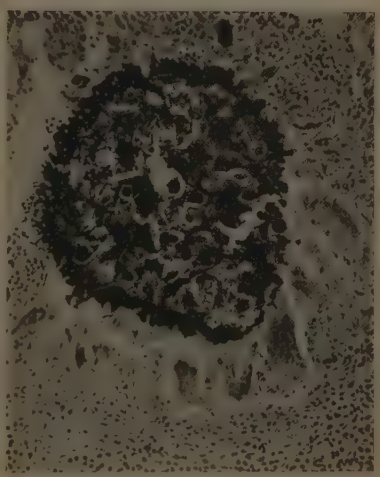

Fig. 558.—Mycetoma (Wright and Brown). Black granule in a section from the lesion. The black, rounded, central mass represents the brownish, hyaline, refringent substance in which the fungus elements are embedded. Giant cells and granulation-tissue are shown.

Symptoms and Course.—Mycetoma begins nearly always on the sole of the foot, more often the right. There may be a history of a slight injury or not, embedded thorns being among the most frequent. A

firm rounded swelling, painless at first, appears, which gradually softens and discharges a thick and syrupy, or a thin and blood-stained fluid holding in suspension the characteristic grains of the disease. Little by little other lumps and fistulas form, until in time a large part of the foot is affected. The member is gradually increased to two or three times its normal size and is greatly deformed, resembling a huge potato in shape. The fistulous tracts seldom heal. The surface of the tumor is either lumpy or comparatively smooth, but the openings of the fistulas are generally in elevations of the skin and are surrounded with unhealthy granulations. As the foot becomes helpless the leg muscles waste. There is little pain, as a rule, and few evidences of cachexia until the end, when after fifteen or twenty years the patient is worn out by the drain on his system. Rarely does mycetoma affect other parts, and rarely, if at all, does it extend by metastasis, thus differing from true actinomycosis. The color of the grains thrown off in the purulent discharge will determine the clinical type of the disease. They are white or yellow in the pale varieties, and black or very dark brown in the melanoid form of mycetoma. In certain cases of the white form the grains are extruded in masses resembling fish roe, and this variety is particularly liable to be attended with destruction of the bones of the foot, which are often spared in other forms.

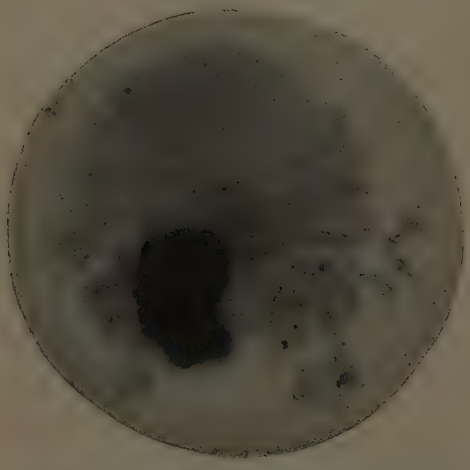

FIG. 559.—MYCETOMA, SHOWING THE OUTGROWTH OF HYPHÆ FROM ONE OF THE BLACK GRANULES AFTER PLANTING IN FLUID CULTURE-MEDIUM (Wright and Brown).

On section the foot is found either diseased in part, with intervening areas of sound tissue, or entirely converted into a structureless mass. Scattered through the foot are large and small cavities; some are isolated, others communicate with each other and by fistulous tracts with the outer world. Their liquid contents are full of the granules. The fungus spreads from various centers in all directions. In the yet solid parts of the tumor granules are seen surrounded by zones of inflammation. The bones and articulations may be unaffected or disintegrated. The histologic features are, briefly: slowly forming granulation and cicatricial tissue; infiltration by lymphoid, epithelioid, and (rarely) giant cells; obliteration of the vessels; and cell degeneration of the part. A determination of polymorphonuclear leukocytes is found in places where the inflammation is more acute. The extending fungus growth, more vigorous at the periphery, is resisted by the living animal tissue. Brumpt believes that new centers of growth are set up by phagocytes wandering off with frag-

ments of mycelium to which they succumb, setting free the parasite. Secondary infection by pyogenic organisms is common enough.

The white granules—mycelial masses with débris of the animal cells—are soft and easily crushed. The black grains are hard and the threads are cemented together by a substance which may come from the animal tissues, but more probably is secreted by the fungus. In the latter case the black grains may be regarded as true sclerotia. In the rare "pink" variety the grains scattered through the tumor and discharged from it resemble ground red pepper. Nothing is known as to the specific etiology of this form of mycetoma.

Treatment.—Nothing can be done with medicines to check the slow but sure progress of mycetoma. Iodid of potassium, so useful in actinomycosis, is useless. Rarely the disease is confined to a small part of the foot—one toe, for instance. In such a case an attempt to exercise the diseased part may be successful in curing the patient permanently. Usually amputation of the foot or of the leg at the point of election is indicated as the only treatment. The disease being wholly incurable, there is no use in delaying amputation after diagnosis is made.

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ENDEMIC ULCERS OF THE TROPICS.

Under this heading may be briefly considered a number of localized diseases of the skin and underlying tissues which have been reported from all parts of the tropical world, and to which so many place-names have been given that the mere enumeration would be tedious.

The reporters have, as a rule, laid stress on the endemicity of the various affections they describe, so that at first glance one would think that each country, district, or even town has its own special "ulcer," "sore," "boil," or "button." Unfortunately, although we have a wealth of clinical description, not a little well-done histologic work, and some very suggestive laboratory researches into the specific etiology of these complaints, it is impossible to approximate as yet a satisfactory classification, for some are ulcers from the first, indolent, serpiginous, or phagedenic; others are granulation tumors followed by ulceration. It is also evident that the diagnosis of "tropical ulcer" is often very loosely made, and that an obstinate ulcer occurring in hot countries or seen in a patient coming thence is apparently so termed, and a special interest attached to a case in no way different from hundreds seen in our city dispensaries and charitable institutions. White men in the tropics, from depraved vitality due to anemia, scurvy, malaria, etc., are very suitable subjects for staphylococcic infections such as boils, carbuncles, and simple ulcers attending the most trivial injuries to the skin. So are the underfed and dirty natives, who, in addition, are prone to many irritative skin diseases.

Syphilis is as common as in Europe or the United States, and its lesions have undoubtedly been described under the head of some at least of the many tropical ulcers.

Omitting any further reference to the so-called endemic ulcers, the causation of which is uncertain and which very likely have no claim to be considered as separate diseases, there remain a few localized affections of endemic nature, about which something really definite is known, and which therefore deserve a brief description. Their consideration here is only for convenience, as it must be confessed there is no special reason for grouping them—either from the standpoint of pathology or etiology.

Oriental Sore or Delhi Boil.—This is a disease endemic in certain towns and districts of India, central Asia, northern Africa, the Levant, and the Malay Peninsula. From the fact that it is at the same time widely scattered over the eastern hemisphere, and quite limited to certain endemic centers therein, it has received a dozen or more local names, such as Bagdad boil, Aleppo boil, Biskra button, Mooltan sore, etc.

The disease begins with itching or burning of the skin over a small area of some exposed part,—the hand, leg, foot, neck, or face, as the case may be,—which skin soon becomes swollen and discolored. A small hard papule now forms in the center of the patch, deep red and shiny, increasing in size until it measures from 0.5 to 1.0 cm. in diameter. The nodule desquamates and a thin serous fluid exudes from it, forming a scab, which by accretions from beneath gives the lesion a rupial aspect. When the scab comes off, there is left an ulcer with sharply defined edges which secretes a thin pus. The ulcer increases by erosion of the margin, and is sometimes added to by the formation of new papules around its edges, which break down in a similar way, the resulting sore being irregular and attaining possibly the diameter of 6 to 8 cm. The ulcer is indolent and intractable to treatment, and its surface is usually granulating, showing proliferation in some parts and breaking down of tissue in others. The course is tedious, often lasting a year, but the deeper structures are not affected in tropical cases, nor are the neighboring glands commonly enlarged. Pain is most often absent. After several months the ulcer loses its indolent character and heals by granulation, leaving a puckered and pigmented scar when cicatrization is complete, which, if on the face, is very disfiguring. On the whole, the picture of a special, self-limited, local infection is presented, reminding one irresistibly of the phenomena of vaccinia, in spite of the difference in the course of the two diseases. Oriental sore is inoculable and, for a period at least, protective against another attack. Recent investigations[2,3] have shown its specific cause to be in all probability an animal organism represented in the lesion by bodies at present indistinguishable from the Leishmann-Donovan bodies of kala-azar and tropical splenomegaly (see Vol. I, p. 141), which are supposed to be flagellates (Herpetomonas) in a certain stage of development. James[4] found the organism at Delhi in thirteen out of twenty cases, but did not find them in a large number of patients in the neighborhood suffering from enlarged spleen, on whom he made splenic punc-

tures. This observer had also studied kala-azar in Siam, and concludes that if the parasites in this fatal disease are identical with those of oriental sore, they are able to produce only kala-azar in Siam, where they are not found in ulcers, and in the Punjab only the special local lesions, never the splenic infection.

Structurally oriental sore is a granulation tumor infiltrating the true skin and replacing its structures, causing atrophy of the epidermis, so that an ulcer results. Infection is probably by inoculation, either directly or through the medium of insect bites.

The disease, if uncomplicated, always results in recovery, and unless the sore is injured or infected by pyogenic organisms there are no constitutional symptoms beyond a certain amount of debility produced by its long duration.

The **treatment,** as directed by those of most experience with the disease, should be expectant. The lesion must be kept scrupulously clean and treated with a simple antiseptic dressing. Protection from injury and secondary infection is very important, as sepsis or erysipelas may ensue. Supporting treatment with generous diet is called for, and removal to a cooler climate is very beneficial. A radical treatment of the disease in its initial stage is advocated by some authorities. It consists of thorough removal of all the tissues involved by excision and by the cautery.

Sloughing Phagedena.—Ulcers of a very virulent nature, characterized by a fetid, grayish, pulpy exudate which infiltrates and destroys the tissues in all directions, are found in several hot countries of both hemispheres. The phagedenic ulcers of Mozambique, of Madagascar, and of Guiana, are almost certainly the same disease, those of Cochin-China probably so. The phagedenic process is a complication of wounds and has a special predilection for the lower extremities, undoubtedly because the legs of the lower classes in hot countries are most exposed to injury and to dirt. Le Dantec,[6] who studied these ulcers in Guiana among the convicts, examined the bacteria in the exudate and found a bacillus in such preponderating numbers that he considers it the cause of the disease. The organism does not grow on ordinary media, and does not become decolorized by Gram's method. Infection is believed to come from the soil and to be carried from infected wounds to clean ones by flies or by direct transference. Inoculation through an injury of the skin is probably necessary to establish the disease, which often begins at the site of a leech bite or the burrow in the skin made by the sand-flea or chigger. Only total destruction of the parts infiltrated by the exudate stops the progress of the ulcer, an object best attained by curetment and the application of strong carbolic acid under anesthesia. Le Dantec believes this disease to be nothing less than the hospital gangrene formerly such a terror to our surgical wards, and now fortunately extinct in Europe and the United States.

Zambesi Ulcer.—A phagedenic ulcer occurring in tropical Africa, and perhaps identical with the foregoing, has been described by Ashley-Emile,[7] who determined the cause to be the larvæ of a dipterous fly which

is found in the long grass of the Zambesi valley, and which adheres to the naked legs of persons walking therein. The grub burrows through the epidermis into the subcutaneous tissue by way of a hair-follicle, where it lies coiled up around the hair-root. In this situation the lesion resembles a hard pimple with a central black spot which is the worm itself. After about twelve hours the worm excretes a yellow fluid of a very irritant nature, which rapidly causes an inflammatory areola around the nodule. The larva now disappears beneath the superficial fascia, leaving the vesicle in its place, which attains, if left undisturbed, the size of a marble and bursts after a few days. In the meantime, however, disintegration has taken place beneath the superficial fascia, which now begins to break down, so that in a couple of weeks a circular ulcer with indurated, sharply cut edges, surrounded by a congested area of dusky red color, appears. The surface of the ulcer is covered with a gelatinous, stringy, adherent slough. The tendency of the ulceration is to spread laterally and more deeply into the tissues; the underlying muscles are destroyed and the bones denuded of periosteum, resulting finally in great deformity.

The site of these ulcers is almost invariably on the lower extremity, generally on the anterior aspect. There are no marked constitutional disturbances. If the worm is discovered in the first few hours, it may be extracted with the point of a scalpel and further trouble avoided, but after it has penetrated the fascia it becomes difficult to extract it. After the establishment of the ulcer, thorough curetment and cauterization are demanded.

Veld Sore.—In the South African war both British and Boers were afflicted with a peculiar form of superficial ulcer, which though not serious in type caused a great amount of annoyance and even suffering, as well as loss of strength to the fighting forces. This affection differs in many ways from the other endemic ulcers described. It occurs in an elevated, dry climate, among men in excellent physical condition. It is inoculable, yet during the war it affected only the white Englishmen and Boers, neither negroes nor East Indians suffering at all, though they were in constant contact with the white troops. According to Harman,[8] who has given us the best description of the disease, it is extremely superficial, affecting only the epithelium, and being surrounded by a fringe of exfoliated tissue and areola of inflammation. The favorite site is on the exterior surface of the upper extremity from elbow to fingers; also, but much less frequently, the sore occurs on the peroneal surface of the leg. The ulcers begin at the sites of small injuries, so that scratches and abrasions of the most trivial nature instead of healing become inflamed, and alongside a delicate blister appears, which bursts, leaving the veld sore. The development of the blister is either rapid or slow, and it attains sometimes a diameter of several centimeters. The resulting shallow ulcer continues to spread, resisting ordinary treatment, until it may cover the whole of the back of the hand. The floor of those of long-standing becomes tough and leathery, with fresh looking edges fringed with ragged epithelium. A true ulcer may now result because of pyogenic infection and attack the corium proper. The veld sore lasts for months, often

scabbing over under a single dressing, but the scab is soon floated off by thin pus, leaving the surface again denuded. When healing finally begins to take place it is rapid and complete, leaving very little trace, only a shiny discoloration of the skin, which will in all probability disappear in a few years.

Veld sore is auto-inoculable and is communicated to others by contact, yet it is not self-protective, for after a series of sores have been healed up a second crop may occur months later. Harman believes a predisposing cause of the affection to be a scorbutic condition due to the absence of fresh food in the field life of the veld. The troops were too well taken care of to develop old-fashioned scurvy, but nevertheless were largely fed on tinned rations. The Boers too were sufferers, although it is said that in peace time, while living on their farms, the sores were unknown among them. The specific cause of veld sore was determined by Harman to be a micrococcus which he names M. vesicans, commonly occurring as diplococci, and singularly resistant to heat and germicide drugs.

The **treatment** of the disease requires attention to the general bodily condition, as the sores improve rapidly under rest and a generous dietary. The ulcers should be well cleansed with a solution of mercuric chlorid 1:1000, taking special care to remove all the ragged fringe of epithelium which undoubtedly contains the infective agent and keeps up the spreading of the ulcer. As wet dressings are impracticable in the field outside of a hospital, after thorough disinfection the ulcer should be dusted with calomel and a little absorbent cotton fastened over it with adhesive strips. If the floor of the sore is very callous from long duration, it should be vigorously stimulated by rubbing until slight bleeding takes place.

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YAWS OR FRAMBESIA TROPICA.

Yaws or frambesia tropica is an endemic disease of the tropics running a chronic and tolerably regular course. It is contagious, inoculable, and one attack confers a certain degree of immunity. The characteristic lesions of yaws are raspberry-like papillomata on the skin in various situations and in which the infective agent is present.

Yaws is found in all the quarters of the tropical world, and is an exceedingly common disease among the colored natives in the West Indies, South America, the West Coast of Africa, Madagascar, Ceylon, Java, and

many of the islands of the Pacific. The number of native names given to the disease in these various localities is very large; *pian* in the French West Indian dialect, *boba* in Brazil, *coko* in Fiji, *parangi* in Ceylon, etc. The disease was formerly looked upon as a somewhat attenuated form of syphilis,[1] with which indeed it has much affinity. The actual identity of the two is, however, not now generally accepted. The specific cause of yaws has hitherto been as mysterious as that of syphilis, but now there seems to be much likelihood that the etiology of both diseases will be made clear, along similar lines. In 1905 Castellani[2] found in eleven out of fourteen cases of yaws, a spirochæte (S. pertenuis) practically indistinguishable from the organism found by Schaudinn in the lesions of syphilis, the now well-known *treponema pallidum* (Spirochæta pallida). (See Vol. I, pl. xv.)

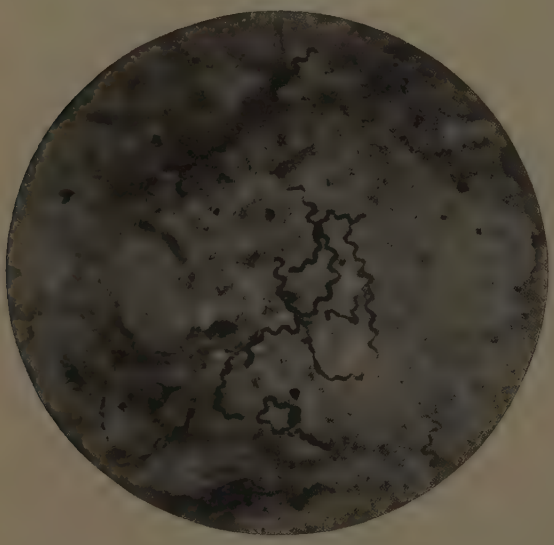

Fig. 560.—Yaws. (Photo by W. M. Gray, Army Medical Museum).
Section showing spirochetes; × 1500, Levaditi stain.

Symptoms and Course.—From inoculation experiments[6] as well as from clinical observation there is an incubation period of yaws of from two to seven weeks, and when a disease is purposely induced, the initial lesion appears at the site of inoculation in the shape of a papule which later softens, ulcerates, and heals under a crust. This initial papule may be overlooked in the typical general eruption of yaws which appears very soon after or which may even accompany it. It is seldom possible positively to recognize the original point of entry in cases naturally acquired by contagion. The general eruption is papular and scattered over the body. At first of pin-head size, some of the papules increase in bulk until they become as large as marbles. The epidermis over the nodule cracks, showing a raw granulating surface, exuding a yellowish, seropurulent fluid. The growths are discrete, as a rule, but may coalesce and form irregular shaped masses or rings. Sometimes one of the nodules becomes much larger than the others, showing less tendency to heal, and occasionally ulcerating in all directions with much destruction of tissue. This is known as the "mother yaw," and it may possibly develop from the primary papule.[2] The eruption goes on for several months with successive crops of nodules. If the hygienic conditions are bad or the case is improperly treated, the eruptive stage may be prolonged for a year or two.

The constitutional symptoms during this stage vary with the case; the patient may remain in fairly good health, or there may be much debility with fever, wasting, and anemia. The lymphatics are swollen in the severe cases, but this is not a regular feature of this disease as it is of syphilis.

The tendency of yaws is toward a cure in about six months, but some cases are more protracted. The nodules dry up and fall off, leaving a discolored spot on the skin. When they are irritated or when the patient is in a depraved physical state from dirt or misery, the lesions instead of healing persist, go on to ulceration which invades surrounding tissue, and in a small proportion of cases the end is even death from exhaustion or sepsis. When these severe cases terminate in recovery after, it may be, years of suffering, permanent crippling may remain from cicatricial contraction. Tertiary symptoms following yaws have been described, such as periostitis, ulceration of bone, etc.[1]

The **treatment** of yaws consists of cleanliness, liberal diet, and general good hygiene. Mercury is useful, but must be cautiously used, as it is not the specific that it is in syphilis. Iodid of potassium is, however, of great value, as is also arsenic. Tonics are needed through convalescence. Locally, antiseptic lotions may be used, small chronic growths may be destroyed with carbolic acid or the curet; ulcers scraped and disinfected. As the disease is highly contagious, isolation of the sick, and thorough disinfection of their houses, bedding, and clothing must, of course, be strictly carried out. White residents are by no means immune to yaws, but usually escape because of their better hygiene and by keeping aloof from the natives.

The points of resemblance of yaws to syphilis are indicated in the foregoing brief description, but the points of difference are many, and may be summarized as follows: (1) Yaws most frequently attacks young children, and the lesions, even in adults, are nearly always extra-genital. (2) It is spread by contagion, but can seldom be traced to sexual intercourse. (3) The cutaneous lesions are always true to the type, thus differing from syphilides in general. (4) Yaws undoubtedly existed in many places prior to the coming of the white man with his fatal gift of syphilis. (5) Charlouis,[3] who inoculated yaws experimentally, also inoculated a patient suffering from typical yaws with syphilis, producing a true hard chancre and secondary symptoms. (6) Lastly, MacLeod[4] describes essential histologic differences between the lesions of the two diseases.

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AINHUM.

The name "ainhum" is of African derivation, meaning "to saw," and is given to a curious disease affecting colored races, more particularly the black. It is characterized by a slow amputation of one or more

digits, generally a symmetric separation of the little toes, although other toes or even fingers may be affected. It is prevalent in Africa, in India, and in Brazil.[1] In the United States[2,3] over a dozen cases are on record, all in negro patients. The disease begins with a fissure at the root of the toe, on the plantar surface. Usually the little toes of both feet are affected simultaneously, but one foot may remain sound or subsequently become diseased. The fissure deepens and extends entirely around the digit, without pain, and with very little if any ulceration and no bleeding. The toe, which is being very slowly amputated, enlarges and becomes almost spherical, and finally after several years drops off. The con-

FIG. 561.—AINHUM.

striction is generally at the first interphalangeal joint, but may be around the first phalanx. After separation a small ulcer is left which usually heals without further trouble. The disease is seldom attended with annoying symptoms, and gives, indeed, so little inconvenience to the patients that they may not seek treatment until the last stages. Occasionally the constricting groove may be ulcerated or painful, but this is generally due to injury when the toe has nearly separated. Ainhum is most common in adult males, but the cause of the complaint is entirely obscure. Zambaco[4] believes it to be a very much attenuated nerve leprosy, but the disease, as in Brazil, is common in regions where leprosy is not seen. It is not due, as has been asserted, to the wearing of rings on the toes after the cus-

tom of savages, because it occurs among people where such a custom is unknown (American negroes, for instance, do not wear toe rings) and where shoes are worn. The disease has certainly all the marks of trophoneurosis, resembling in a measure Raynaud's disease and nerve leprosy, but it is quite different from both in many symptoms. According to Unna, ainhum is a sort of linear scleroderma, in which the epidermis hardens and shrinks, compressing the papillary layer and causing pressure necrosis. Obliterating arteritis follows, with degeneration of all the tissues of the toe, including the bone which is the seat of rarefying ostitis. There is no treatment that will preserve the toe after separation has progressed to any extent, but in the unlikely event of making a diagnosis of the disease in its earlier stage, an incision of the constriction, with curetment of hardened tissue, might possibly stop further progress. The partly separated toes should be removed whenever in the least troublesome.

GOUNDOU.

Goundou is a curious endemic disease of the tropics, confined to negroes, in which symmetric bony tumors form and slowly grow on each side of the nose, giving the countenance a grotesque and ape-like appearance. Beginning usually in childhood, small bony excrescences, nearly always bilateral, develop, arising from the nasal processes of the upper maxillary bones, later involving the nasal bones. The tumors continue to grow throughout life, and attain in course of time the size of hens' eggs. They are ovoid with the long axes converging above, smooth, insensitive, and in no way involve the skin, which is freely movable. The structure of the growth is spongy bone covered by a thin compact layer.

FIG. 562.—BILATERAL GOUNDOU (Cannac).

The etiology of goundou is altogether unknown. The disease, if disease it be, is said by Maclaud[1] to affect monkeys, and Strachan,[2] who observed a similar deformity in negro children in the West Indies, suggests that it may be an atavistic survival of the normal features of a remote African ancestry, a suggestion of more interest to those to whom evolution means only that "man is descended from a monkey" than to pathologists.

The Agnis, a tribe of the Ivory Coast, regard goundou as a mark of the wrath of a certain fetish, "Jero,"[1] who is represented as carrying upon his wooden nose the characteristic twin tumors. The victims take no measure

to treat themselves, but look upon the deformity somewhat in the light of a mischievous prank played upon them by the offended divinity.

Goundou does not appear to be hereditary, nor to follow any known disease, although Chalmers[3] believes the tumors to be an osteoplastic periostitis due to yaws (*q. v.*), as he noticed that the affection occurred during or after an attack of that disease. In a number of clinical reports by other observers[4] a history of yaws is noted, but Lopez,[5] describing the only recorded case in Mexico, was unable to get any history of antecedent disease. Goundou occasions no inconvenience, beyond of course its unsightliness, unless the tumors have become very large, in which case the nasal cavities may be partially occluded, or the vision may possibly be obstructed. No treatment short of removal by the chisel is of any avail; this is not difficult, especially when the tumors are small, as in childhood.

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CHAPTER LXIX.

THE INFLUENCE OF RACE, SEX, AND AGE IN SURGICAL AFFECTIONS.

By Wm. L. Rodman, M.D.,
PHILADELPHIA.

In this chapter the consideration of racial differences will necessarily be largely limited to those between the white, black, and Indian races of North America. Undoubtedly there is a difference in the susceptibility of the white, black, and red man to surgical affections, but their environments, changes in climate, mode of living, etc., have greatly lessened the immunity the negro enjoyed when he came to America, and for two centuries subsequently.

During my former residence in Louisville, Kentucky, I had excellent opportunity to study the susceptibility of the negro to various surgical affections, and I found both from personal experience and from an exhaustive study of the records furnished by the Louisville City Hospital and the health officer's reports, supplemented by letters from all of the more prominent surgeons of the south, that not only have the diseases which originally attacked the negro remained as virulent in his new surroundings, but that he is now relatively more liable than the Caucasian to some affections to which he was formerly comparatively immune, such as malignant disease, tuberculosis of glands, skin, and bones.

From ten years' added experience in Philadelphia, with a fairly large colored population, I am convinced that the foregoing statements are not only true of the negro in the south, but are even truer of him as he moves further north into climates and environments to which he is at best ill suited. While I do not altogether agree with such authorities as the late D. W. Yandell, of Louisville, and the late Hunter McGuire, of Richmond, when they said that the negro in North America will in time become as extinct as the North American Indian and the bison, one can readily appreciate some of the reasons for such a statement. It is, however, surgical affections only in which we are particularly interested, and, therefore, I will proceed to discuss the more important of these with reference to race, sex, and age.

Generally speaking, I divide the people of the United States into two special classes, namely, the white and the black; including under white not only the Anglo-Saxon, but also the various white races of Europe which have emigrated to this country, as Italians, Russians, Swedes, Norwegians, Polaks, etc. Under the second general classification, I speak primarily of the full-blooded descendants of Africans, and do not include the mulatto unless especially mentioned as such.

Aneurysm.—Race.—Aneurysms occur, as far as I know, in every race. This seems reasonable, since arterial degenerations are the most important predisposing causes in their etiology, and, the latter are, as a rule, dependent upon syphilis. But there are certain races in whom we encounter aneurysm more frequently than in others. From my experience in the south, and from the opinions of other surgeons of that section, I am convinced that the negro is particularly liable to develop aneurysm. The late Hunter McGuire, of Richmond, Tiffany, of Baltimore, and many others to whom I have written in the past regarding this subject, all say that aneurysm is seen more frequently in the negro than in the white. In the United States Census Report the ratio of 3 to 1 is given against the negro. The records of the health office of Louisville and those of the Louisville City Hospital agree with these statistics. The fact that aneurysms are seen so frequently in the colored race is readily to be explained, since the negro is (*a*) very frequently infected with syphilis and is, therefore, (*b*) prone to arterial degenerations, such as atheroma and sclerosis, and is (*c*) usually a laborer, thus adding the exciting cause, viz., hard work. Camac, in an analysis of 3954 necropsies, concludes that aneurysm is three or four times as common in the colored as in the whites.

In England and Germany aneurysms are said to be common, while in China it is looked upon as one of the rarest affections. The Chinese are phlegmatic in temperament, and live upon a non-stimulating diet, all of which may have some little influence upon the predisposing etiology of aneurysm.

Sex.—The majority of cases occur in men, because of their more marked predisposition to vascular disease, on the one hand, and their occupation and habits on the other. Souchon's series of ninety-eight cases shows seventy-six males and twenty-two females. Crisp, in an analysis of five hundred and fifty-one cases, found it to be seven times more common in men.

Age.—The majority of cases will occur between thirty-five and fifty-five. In a series of cases which I collected none occurred under twenty-five and but three under thirty. The ages of these patients were twenty-five, twenty-eight, and twenty-eight respectively. Fremont-Smith * has called attention to the occurrence of aneurysms in the young. He states that Roger, in ninety-eight cases of aortic aneurysm found but one under twenty years of age. Holmes found thirteen instances of intracranial aneurysm in children, and other such aneurysms were reported by Parker, Crisp, Jacobi, and Keen. Camac, from an examination of the records of seven hundred and ninty-nine autopsies in children, finds no case of aneurysm between one and ten years; but from three hundred and forty autopsy reports of aneurysm in the literature, finds two cases in the first five years of life; in the second five, three cases, and twenty-seven cases in the second decade.

Fremont-Smith also, in his interesting paper, states that in a series of cases forty-six occurring under twenty years of age were clearly due

* Fremont-Smith: "Arteriosclerosis in the Young," Am. Jour. Med. Sci., Feb., 1908.

to local arteriosclerosis. This is of decided interest, since syphilis has usually been accepted as the chief factor in the production of aneurysm. He states further that of this series of forty-six cases, syphilis was mentioned in twelve instances, it being negative eleven times and positive once; also that Camac in extensive researches of hospital reports attributes about 32 per cent. of adult aneurysms to syphilis—about 16 per cent. to tuberculosis.

Other interesting cases occurring in the literature are quoted by Fremont-Smith, such as phenomenal instances of still-born infants with aneurysm of the abdominal aorta so large as to cause dystocia. He also mentions Martin's case of aneurysm of the ductus arteriosus in an infant of one month; Roger's case of aneurysm of the transverse aorta in a girl of ten; Eppinger's case of aneurysm of the right and left coronary arteries at their origin in a girl of ten years, and Camby's case of aortic aneurysm in a girl of fourteen years. He quotes these cases as examples of non-specific aneurysms. His careful review of the literature has borne interesting results, and shows us that aneurysms do occur much more frequently in the young than has been thought.

The disease again becomes comparatively rare after sixty.

Congenital Deformities.—The savage races, as the North American Indian and the African, seem to enjoy a partial immunity to all congenital deformities. There are but few reported instances of harelip, cleft palate, club-foot, spina bifida, etc., occurring in either of these races. This may be explained in the case of the North American Indian by the fact that deformed children are soon put to death after birth. This practice does not obtain with the negro. Therefore a further explanation has to be sought. It would seem that civilized races are possibly more prone to bear deformed children on account of their artificial mode of living.

However, the influence of heredity upon congenital deformities is still speculative, and, therefore, no one can speak with authority. It would seem also that congenital deformities are of infrequent occurrence in the Jews, Mexicans, Chinese, and Japanese.

Erysipelas.—Age.—The two extremes of life suffer from this disease most frequently, young adults and middle-aged persons having it but rarely.

Sex seems to have but little, if any, influence.

Race.—The total number of deaths due to erysipelas in one year, as reported in the United States Census Report, was 2663. The death-rate per 100,000 inhabitants was as follows:

Under five years	31.34 per cent
Five to fifteen years	0.81 " "
Fifteen to forty-five years	2.80 " "
Forty-five to sixty-five years	8.88 " "
Sixty-five and over	38.55 " "

Of this series of cases, only two are reported in colored persons. This may, however, be explained by the fact that the diagnosis of erysipelas in the negro is difficult, inasmuch as his dark skin often causes an erysi-

pelatous inflammation to be overlooked. In my series of seventy-nine deaths reported from erysipelas, seventeen were negroes; this is slightly less than an equal proportion between the two races in Louisville, the population being 4 to 1. I should, therefore, say that erysipelas is not quite so frequently seen in the colored as in the white.

Goiter.—So meager is the literature regarding the frequency of goiter, colloid, cystic, or exophthalmic, with respect to race, sex, and age that definite conclusions are impossible. Much, however, has recently been written on the pathology and surgical treatment of affections of the thyroid gland. I have seen few cases in the negro and believe goiter to be rare in this race. Of the many surgeons to whom I have written within the year, but few have seen goiter of any variety in the colored race. McRae has seen one case; Payne many cystic and one exophthalmic; Brown one colloid and one exophthalmic; Wathen two cystic and one exophthalmic, and Lenow one colloid. Bloodgood states that almost every lesion of the thyroid gland has been observed in negroes at the Johns Hopkins Hospital, but he considers them comparatively less frequent in negroes than in whites. C. H. Mayo, who is undoubtedly operating for goiter more frequently than any one else in this country, has never seen a case in the negro, though this may be partly explained by the fact that negroes are rarely met with at the Rochester clinic, since there are but a very few in the northwestern States. It is certain, however, that goiter, while practically seen everywhere, does occur with greater frequency in some locations than in others. It may be endemic, as, for instance, in certain parts of Switzerland, while in other parts of the same country it is extremely rare. This is in keeping with the accepted idea of the etiology; namely, that certain qualities in the drinking-water are responsible for the irritation and enlargement of the thyroid. Kocher states (see Vol. III, Keen's "Surgery") that when endemic, goiters are usually of the colloid variety, and that persons previously unaffected may develop goiter after going to a community where the disease is prevalent. Goiters are also common in Germany, and are often seen elsewhere on the Continent, as in France. In parts of Pennsylvania, as Indiana and Clearfield Counties, goiters are very common.

Sex.—All varieties of goiter are somewhat more common in women than in men. Especially in this true of the exophthalmic variety, yet I have treated two well-marked cases in boys, aged fifteen and seventeen respectively.

Age.—No age seems to be exempt. The disease is most common, however, from the thirtieth to the forty-fifth year. In a series of cases collected by myself the average age was thirty, which corresponds fairly well with my own clinical experience.

Appendicitis.—Race.—Appendicitis is of more common occurrence in whites than in blacks. Possibly this may be explained by the fact that appendicitis is often associated with digestive disturbances, and, since the negro lives, as a rule, upon a more simple diet, he is not so liable to gastric disorders.

While living in Kentucky, I operated frequently for appendicitis, and

only once did I encounter the disease in a full-blooded negro. I have seen it several times apparently in full bloods during the last ten years passed in Philadelphia. A large number of surgeons of the South, in answering a circular letter, assured me that my experience has been the same as their own.

However, as is true of many other diseases, the negro is becoming less resistant to appendicitis, and that we shall find it more frequently in the future I have no doubt. It is not uncommon at the Pennsylvania Hospital in this city, where, perhaps, a larger number of negroes are operated upon than in any other hospital in Philadelphia.

Furthermore, appendicitis is either on the increase in nearly every country and with every race, or its recognition has been made easier with both the profession and the laity.

Sex.—Appendicitis affects men more frequently than women. Some go so far as to state that it occurs in the male four times as frequently as in the female. My experience has led me to believe that the disproportion between the sexes is not so great as this, but I am convinced that it is undoubtedly more common in men, occurring in my practice in the ratio of about 2 to 1. The reason for this fact has never been thoroughly understood, but various theories have been advanced, the more important of which seems to be the one based upon an anatomic difference, namely, that the appendix in the female is supplied by a small branch from the ovarian artery in addition to the vessels which nourish it in the male. Therefore, with a better blood-supply, degeneration and inflammation are, of course, less apt to occur.

Age.—It is well known that appendicitis belongs to young adult life, but cases at all ages have been met with. The disease is common between fifteen and thirty-five. It is infrequently seen in children less than five years of age, and there are relatively but few cases reported under ten years of age, the liability after that being progressively increased with each quinquennium up to the thirty-fifth year. The average age in a large series of cases was approximately 23.14. In Fowler's experience the youngest patient was 2.5; the oldest sixty-eight. In the youngest patient the disease was tuberculous in character, this being the only case occurring under five years of age. Following is a table compiled by the late Dr. Fowler, taken from the "Annals of Surgery":

	CASES.
Between five and ten years	8
" ten and fifteen years	21
" fifteen and twenty years	29
" twenty and twenty-five years	43
" twenty-five and thirty years	23
" thirty and forty years	28
Over forty years	16

Acute Intestinal Obstruction.—I shall only discuss under this heading that type of obstruction which is acute in origin, independent of any congenital malformation, since it would seem that this type has a more direct bearing upon the subject. In considering acute ob-

struction, we have: (1) invagination or intussusception; (2) impaction of foreign bodies, notably gall-stones; (3) volvulus or twisting of the bowel upon its axis, said to be dependent upon an elongation of the mesenteric attachment of the gut; (4) internal strangulation due to either an inflammatory band, a Meckel's diverticulum, or a protrusion of gut through some internal opening.

Intussusception.—About one-third of all cases of acute intestinal obstruction are caused by intussusception. According to W. Brinton, who analyzed 12,000 cases post mortem, intussusception approximately causes 33 per cent. of all cases. Some place the figures higher, such as Lichtenstein and Fitz, who give the percentage at 38, and others as low as 30. As is generally known, intussusception is pre-eminently an affection of infancy and early childhood. Holt, in a series of three hundred and eighty cases of intussusception in children, found that one hundred and forty-one were under six months and eighty-nine between six and twelve months; thirty-two between the first and second year; ninety-six between two and ten years. Therefore it will be seen that considerably more than one-half of these cases collected by Holt occurred within the first year.

Sex seems to have some influence, as it was encountered more frequently in male children than in females, there being one hundred and seventy-four of the former against ninety-four of the latter. As age advances intussusception is said to be a more frequent occurrence in males than in females. At least one-half of all cases occurred at the ileocecal valve, the remainder occurring in the small intestine twice as frequently as in the colon.

Impaction of Foreign Bodies.—Foreign bodies, such as gall-stones, may occasionally cause intestinal obstruction. In looking over records of reported cases, I find that this is the cause of about one case in fifteen of intestinal obstruction of the acute variety. When it is the result of gall-stones, the symptoms of obstruction are less acute than usual.

I have seen two cases caused by impaction of enormous gall-stones, both in elderly white females. Extraneous foreign bodies may rarely cause intestinal obstruction, these cases occurring, as a rule, in children who are apt to swallow such objects. Cases due to fecal impaction are usually in elderly subjects, the majority being women.

Volvulus.—Since volvulus depends presumably upon elongation of the mesentery, it is, therefore, apt to occur in elderly subjects with greater frequency. However, cases have been seen in children, due in all probability to congenital lengthening of the mesentery. Volvulus, however, is a rare cause of acute intestinal obstruction, and occurs, as I have said, with greater frequency in elderly people whose mesenteries are elongated from frequent strain.

Internal Strangulation.—This form of acute intestinal obstruction is met with more often than all others. It is due, as has been said, either to an adhesive band, a Meckel's diverticulum, or protrusion of the gut through some internal opening, as internal hernias. This variety is met with in patients between the two extremes of life, since occupation, ex-

posure, and diseases to which we are liable during the active period of life increase our susceptibility to obstructions of this variety. It occurs with about equal frequency in both sexes, often following the formation of adhesive bands in men with appendicitis and women with pelvic inflammations.

Intestinal obstruction is apparently less frequently met with in the colored race, since they are somewhat less liable to intestinal diseases, as appendicitis, etc.

Gastric Ulcer.—Race.—Gastric ulcer is more commonly seen in Germany and England than anywhere else. Combined statistics from seven cities in Germany show that the average frequency of gastric ulcer as determined by post-mortem examinations is 5 per cent. This is somewhat greater than the percentage shown by early investigations. Brinton's estimate of 5 per cent. for England has long been considered correct. Out of 59,762 medical cases in the London hospitals, however, H. A. Hare states that 1649, or 2.7 per cent., were cases of gastric ulcer. However, it has long been thought to be more common in England than it is in America. According to Hare's statistics, its incidence is more than four times as great in the former as in the latter country. The combined statistics of five Austrian investigators give an incidence of 3.8 per cent. for that country. Two series of cases from Copenhagen give an incidence of 12 per cent. Recent investigations carried on in Finland give an incidence of 2.14 per cent. In Russia gastric ulcer is rare. Thus, out of 6000 autopsies made in St. Petersburg only two cases were found (Petersen). At the Marien Magdalen Hospital, St. Petersburg, there is an average admission of 3500 to 3750 patients yearly, yet no case of gastric ulcer during one entire year was seen. Donati's statistics show a percentage of 1.5 per cent. for Italy at the most, including all cases of benign stricture of the pylorus in the category of ulcer. Of 62,598 patients admitted to Ospedale di S. Giovanni in Turin from 1894 to 1903, 90, or 1.437 per cent., were diagnosed as ulcer. Adding to this the forty-nine patients suffering with benign stricture of the pylorus, we bring the total percentage to 2.22 per cent. Post-mortem records from the pathologic department of the University of Turin corresponded closely to the clinical record. In more than 8000 autopsies the percentage of gastric ulcer was found to be 2.6. Sperk states that gastric ulcer is very common in eastern Siberia, and Palgrave is quoted by Welch as stating that it is of frequent occurrence in Arabia. Post-mortem records from the Edinburgh Royal Infirmary based on 35,692 cases show the incidence of gastric ulcer to be 2.2 per cent.

In this country gastric ulcer is more often seen in whites than in blacks. A recent statistical study was made by J. A. Storck, of New Orleans, showing that this disease is rare in the negro. He quotes the records of the New Orleans Board of Health, which show the total mortality in that city from 1893 to 1903 to be as follows: whites, 48,550; blacks, 30,012. Deaths from ulcer of the stomach in the two races during this decade were whites, 60; blacks, 13. Furthermore, in a study of 6800 medical cases in whites he found that there were fifty-eight cases of gastric ulcer, whereas in 4900 medical cases in negroes, there were only two

cases of gastric ulcer. I have never seen a case in the negro in which the symptoms were definite enough to warrant a diagnosis of gastric ulcer. None of the surgeons to whom I have written about this subject report any such case, except Brown, of Birmingham, Ala., who reports "one supposed case. No operation. Death from hemorrhage of stomach. No autopsy"; and Bloodgood, of Baltimore, who believes the negro to be as frequently affected as the white. W. J. and C. H. Mayo have never had a case of ulcer of the stomach in a negro.

Sex.—Statistics show that gastric ulcer is more common in women than in men. Berthold found ulcer in 3.84 per cent of all the female bodies he examined post-mortem and in 2.06 per cent. of the male bodies. Steiner's statistics are 4 per cent. for females and 3 per cent. for males; Lebert's, 10 per cent. for females and 7 per cent. for males; Willig's, 7 per cent. for females and 2.02 per cent. for males; Nolte's, 1.8 per cent. for females and 0.8 per cent. for males. The Fenwicks make the ratio 3 to 1 in favor of females. Greenough and Joslin state that at the Massachusetts General Hospital gastric ulcer is five times more common in women than in men. At the Würzburg clinic there have been for many years twice as many cases observed in women as in men. Of the ninety cases studied by Donati of Turin, fifty-six were women and thirty-four were men. A collective investigation made by H. A. Hare, based upon reports of 1548 cases in England and the United States, showed that 1273 occurred in women and 275 in men. Cantlee states that of eighty-five cases of gastric ulcer seen in Montreal, only three were men. Gluzmski, of Lernberg, however, found that 59 per cent. of his cases were in men and 41 per cent. in women. Buckman, of Helsingfors, states that of 207 cases in the University Clinic of that city, 142 were men and 65 women. Of 737 cases of gastric ulcer, the reports of which he collected from the various parts of Finland, 396 were in women and 361 in men.

It will be noticed that these statistics show considerable variations. My own belief is that acute ulcer only of the stomach is more common in young women than it is in men. Chronic ulcers are more common in men, and are the ones which come to operation, as they are not amenable to medical treatment. That the incidence of the disease is about the same in both sexes after the age of twenty-five or thirty is shown by recent investigations, notably those made only a few months ago by W. M. Calwell, of Belfast, Ireland. Although the statistics above quoted are the most complete I have been able to obtain, I do not consider them adequate for the determination of the liability of the two sexes to gastric ulcer. Further observations must be made, particularly by surgeons at the operating table; in post-mortem examinations distinction must be made between recent ulcer, chronic ulcer, and scars; and modern methods of diagnosis must be more frequently employed by physicians in hospital and private practice. In this way a better understanding of the matter will be obtained.

W. J. Mayo, who has studied this subject and made accurate observations at the operating table, has shown that ulcers which have been

thought gastric are in reality duodenal in a majority of instances. They are also vastly more common in men.

Gall-Stones.—Race.—I formerly thought that gall-stones occurred in full-blooded negroes with extreme rarity. During my entire surgical experience of fifteen years in Louisville, Ky., I never saw a case in the colored race. In 1898, when preparing my chairman's address to the Section on Surgery of the American Medical Association, which embraced the subject considered in this chapter, I made a careful study of the subject and went over the records of the Louisville City Hospital, but failed to find a single case of gall-stones in the full-blooded negro, either in the clinical or post-mortem records. I wrote to the leading surgeons of the south, and Tiffany, and others equally experienced, replied that they had never seen a case of gall-stones in the black race. The late W. E. B. Davis, of Birmingham, reported one case in a mulatto. During the ten years passed in Philadelphia I have not encountered gall-stones in a negro but once in any of the five hospitals with which I am connected, and have heard of but a few cases in the practice of colleagues here and elsewhere.

The case referred to was in a negro woman about forty in my service at the Philadelphia Hospital. She had previously been operated on at the Jewish Hospital for gall-stones. It is one of the few instances of gall-stones recurring after operation. There was an interval of four years between the two operations. At the last operation a stone blocked the cystic duct.

There have been several cases at the Pennsylvania Hospital, in either mulattos or full bloods, and I have also had a few cases reported to me by southern surgeons. Therefore I am inclined to believe that gall-stone disease, while very rare in the negro, does occur now and then, and that modern diagnostic methods will bring it to light more often.

In a series of cases kindly gone over for me by Warfield T. Longcope, of the Pennsylvania Hospital, I find that there were thirty-one cases of gall-stone disease in 1050 autopsies. Of this number fifteen were males; sixteen females. There were:

Under thirty years of age	1 case
From thirty to forty years	5 cases
" forty-one to fifty years	14 "
" fifty-one to sixty years	6 "
" sixty-one to seventy years	4 "
Over seventy years	1 "

Sex.—Gall-stones occur far more frequently in women than in men. This is readily understood, since a sedentary life and tight lacing are recognized as probable etiologic factors. This is also to be explained by the fact that women are more predisposed to stomach, liver, and bowel troubles, especially constipation, and infection of the gall-bladder and ducts is, therefore, more likely to occur.

Age.—The predisposing factors in the etiology of gall-stone disease are concomitant with middle and old age. People under thirty rarely suffer, yet a reasonable number between twenty and thirty and a few under twenty have been reported to me by W. J. Mayo and W. H. Wathen.

The following table, appropriated from Moynihan's monograph on the subject, was compiled by Schroeder, from a series of post-mortem examinations:

Age of Patients.	Number of Post-mortems.	Number of Cases with Gall-stones.	Percentage of Cases Examined in which Gall-stones were Present.
0 to 20	82	2	2.4
21 to 30	188	6	3.2
31 to 40	209	24	11.5
41 to 50	252	28	11.1
51 to 60	161	16	9.9
60 and over	258	65	25.2

In more than 9000 autopsies gall-stones were found by Naunyn in one case in every thirty; in persons past sixty, one in every six. However, post-mortem statistics are unsatisfactory in settling the question of age as a predisposing factor, since it is impossible to tell from such statistics the age at which symptoms first manifested themselves. In the experience of the Mayos, Moynihan, Mayo Robson, and Murphy, all of whom are doing at the present time a large amount of gall-bladder surgery, the average age of the patient was approximately forty-five years, and according to Moynihan, the average duration of symptoms was five and a half years. This coincides with my own experience. Cases of gall-stones in the newborn have been reported by Lieutaud, Vallaix, Still, and others.

Vesical Calculus.—Race.—The negro is less immune to this affection than has hitherto been believed by many surgeons. It occurs once in every 11,732 whites and once in every 55,305 blacks. It will be seen, therefore, that this affection is nearly five times as frequently seen in whites as in blacks. However, stone in the bladder occurs everywhere, affecting every race, but undoubtedly is found in some countries more frequently than in others. In North America it is found most frequently in Kentucky, Tennessee, Ohio, Missouri, North and South Carolina, Virginia, and Georgia. It would seem that New England is relatively exempt, as are also Mississippi, Alabama, Arkansas, Louisiana, and a few other Southern States. Stone is common in France, Austria, Hungary, and Russia, while it is but seldom seen in Spain and Switzerland. It is also frequently seen in England, but less so in Ireland. It is very common in India. According to Gudgeon, of Pekin, gravel and calculus are among the rarest of affections in China. Stones, however, are common enough at Canton, but are of infrequent occurrence at other points. This is hard to explain, as Gudgeon states that the drinking-water and habits of life are the same here as at other places. It has been suggested that opium-eating had some influence in lessening the liability of the Chinese as a race to stone. Certainly it is not the drinking of limestone water, as river-water is universally drunk and very generally boiled before drinking. Little cold water is drunk in China.

From the statistics furnished me by my surgical friends in the medical

corps of the United States army, I judge that vesical calculi are also of uncommon occurrence in the North American Indian, and the few cases reported may be generally traced to traumatism, a nucleus in the bladder inviting the deposition of solid constituents of the urine around it. A sufficient number of cases have been reported in Mexicans to lead me to think that these people are perhaps more frequently affected than other dark-skinned races of North America.

Sex.—In a series of cases collected by George Ben Johnston, of Richmond, Va., sex was specified in 708 cases, there being 691 in males and 97 in females, the entire series comprising 1068 cases. Thus it will be seen that, judging from this series, vesical calculus is about seven times as common in men as in women.

Age.—Gross analyzed 6042 cases of urinary calculi with reference to age and found that:

2334	occurred	from	first to tenth year
1079	"	"	tenth to twentieth year
513	"	"	twentieth to thirtieth year
353	"	"	thirtieth to fortieth year
422	"	"	fortieth to fiftieth year
536	"	"	fiftieth to sixtieth year
587	"	"	sixtieth to seventieth year
201	"	"	seventieth to eightieth year
17	"	"	eightieth to ninetieth year

From this table it will be seen that more than one-half of the cases occurred within the first two decades of life, and that the first decade furnishes more than double as many cases as the second; the latter more than double the number of cases of the third. This ratio is maintained until the sixth decade, when an increase is noted. This increase becomes still further altered in the seventh decade. When it is considered that there are fewer persons living in the seventh decade than in the first and second, the ratio for both extremes of life is about the same.

Stone in the Kidney.—What has been said of vesical calculi will prove true of stones in the kidney. These are of more common occurrence in the two extremes of life. Males suffer about twice as often as females, and some would make the disproportion greater, viz., 3 to 1. On the other hand, there are some excellent authorities, such as Duplay and Reclus, and others, who consider the two sexes equally liable. However, it would seem to me that the disproportion which exists between the two sexes in vesical calculi does not obtain in the renal variety for obvious anatomic reasons. The short capacious urethra of the female usually allows gravel to pass, while in the male they remain in the bladder and act as a nucleus for future stones.

Varicose Veins.—Age.—Varicose veins of the limbs being dependent upon poor circulatory support, are rarely seen in persons under thirty.

Race.—Varices are infrequently encountered in negroes, Indians, Mexicans, and Chinese. They are frequent in whites.

Of twenty-three cases of varicose veins of the leg without ulcer there was but a single case in the negro. This case was in a male aged forty-

four. Of twenty-nine patients with varicose ulcers, there was only one negro, a man of fifty-three.

Sex.—Varicose veins are naturally more commonly seen in men than in women, because of the differences in occupation and the greater liability of men to such predisposing causes as alcoholism, cirrhosis of the liver, and diseases of the circulatory apparatus. In forty-five cases seen by me, thirty-two were males and thirteen females.

Varicocele.—Race.—I have operated upon one well-marked case of varicocele in a negro boy since coming to Philadelphia in 1898. During my entire experience in Louisville, I never knew it to occur, either in my own practice or in that of any other Louisville surgeon. The fact that it does occur so very rarely in the negro has always been interesting to me and has led me to make a careful investigation into the subject.

I collected 600 cases of varicocele operated upon in Louisville and found not a single instance in the negro. In reply to a circular letter sent out at the same date, the late John P. Bryson, of St. Louis, assured me that he had "no record or memory of such a case occurring in the negro." Others, as the late Hunter McGuire, of Richmond, Va., J. William White, of Philadelphia, Tiffany, of Baltimore, Bull and Coley, of New York, expressed themselves similarly.

The reasons for this apparent immunity to varicocele in the negro seem to lie in the following facts: first, that the negro begins sexual life at puberty; and, secondly, that his scrotum is close-fitting, thus affording better support to the testes, keeping them higher and consequently preventing traction upon the veins of the pampiniform plexus, thus rendering them less liable to dilatation.

Various army surgeons have told me that varicocele is very uncommon among Indians. I should think that this would follow for the same reasons as given for the negro.

Age.—Varicosity of the pampiniform plexus with its attendant vague discomfort belongs essentially to that period of life which follows puberty and precedes marriage; namely, adolescence. It is rarely encountered after twenty-five and seems to disappear in those whose sexual life is established. Between the ages of fifteen and twenty-five, therefore, it is exceedingly common. In considerably more than five hundred patients upon whom I have operated for this trouble, I have found the above statements correct. The oldest patient that I ever had was a married man fifty-seven years of age. This was a very well-marked case in which the pampiniform plexus was very large and the symptoms so troublesome as to incapacitate the patient for work. The pressure in the groin was distressing, pain in the back was constant, and the attendant neurasthenia pronounced. Operation effected prompt relief.

Enlarged Prostate.—Race.—Simple hypertrophy of the prostate is rarely seen in the negro. At the time of my former paper on the subject of "Influence of Age, Sex, and Race in Surgical Affections," I found that in the experience of such men as the late Hunter McGuire, of Richmond, John P. Bryson, of St. Louis, and many others, including colleagues with

whom I was associated in Louisville, as Grant, Roberts, Vance, Cartledge, and Samuel, all of whom have had a large practice among the colored race, enlarged prostate was infrequently found among the negro population of our hospitals. H. H. Mudd, of St. Louis, reported a case of hypertrophy of the prostate in a colored man twenty-seven years of age, which, however, later proved to be sarcoma, and, therefore, cannot be included under this heading. Recent information from Young, Bloodgood, J. R. Wathen, Abell, and other southern surgeons indicates, however, that in these days of frequent prostatectomies the negro is furnishing a very small proportion of the cases.

My own experience leads me to believe that hypertrophy of the prostate is common enough as a senescent change in whites over fifty, but as I have rarely seen an instance of the disease in the colored race, I should think, with those whom I have quoted, that the negro enjoys a relative immunity to this affection. I am unable to say whether enlarged prostate is of common occurrence in such races as the Chinese, Japanese, and other dark-skinned races, but believe it to be a rare occurrence in the North American Indian.

Age.—Hypertrophy of the prostate is essentially an affection of advancing years. It rarely occurs under fifty, being quite common after that until the seventy-fifth year, when it again decreases in frequency. Thompson states that 34 per cent. of all men beyond fifty show enlargement of the prostate; 16 per cent. of these suffering from mechanical disturbances of the urinary function. Such is also the experience of Keyes, White and Martin, and others.

Ovarian Growths.—Ovarian growths occur, as far as I know, at all ages and in all races. The more usual variety, of course, is cystic in character, either simple or dermoid, and both may be congenital and only await the stimulation which puberty brings to awaken them into renewed life.

Race.—As I have said, ovarian growths are exceedingly common and occur in all races. Much has been written as to the immunity of negroes to this type of tumor. That it is not borne out by operative experience and post-mortem statistics, I was able to show in a former paper on the subject.

Authentic records show that approximately there are one-third as many deaths from ovarian tumors in the colored race as in the white. This shows a percentage against the negro, since these records were taken from a city in which the population was one colored to four whites. Despite these statistics, ovarian growths are unquestionably less common in the negro, and the heavier mortality with them is explained by the fact that they are poorer surgical subjects, and, as a rule, have less skilled abdominal surgeons to attend them. Ovarian disease of all kinds is relatively on the increase at the present time in the colored race.

Authentic records do not lack for instances of operations done for simple and dermoid cysts in children. However, notwithstanding this fact, we may say that ovarian growths in both extremes of life are comparatively rare. To quote several instances of extreme ages at which ova-

rian cysts have occurred, we may say that d'Arcy Power, of the Victoria Hospital, operated upon an infant four months old, removing an ovarian cyst containing fifty-nine ounces of fluid. Many others, as Hoffman, Bush, de Santa Ana, Schwartz, Barker, Rein, Thornton, Lucas, Haymaker, Cuplees, and Chenowerth haye also reported cases under seven and one-half years. Sir Spencer Wells, whose operative experience in the pioneer days of ovariotomy was extremely large, reports operations in children under ten years of age. As has been said, ovarian growths also occur in the other extreme of life, cases having been reported at the ages of eighty, eighty-one, and eighty-two. No doubt many more cases could be found in a more thorough search of the literature, but these are sufficient to prove the point in question. However, by far the greater number of ovarian growths, solid and cystic, occur between the ages of twenty and forty. The solid varieties of these tumors have usually proved to be either sarcomata or malignant papillomata; the latter may often be cystic.

Ovarian cysts may attain enormous size, the largest one to my knowledge having been reported by Cartledge, of Louisville; it weighed 245 pounds. Other enormous cysts have been reported by Keen, of Philadelphia, and others.

Malignant disease—sarcomata and malignant papillomata—may occur in the ovary. Sarcomata are found much more frequently before puberty than afterward. Twenty-five per cent. of the patients having sarcoma of the ovary die from any surgical interference and nearly all within a year after the beginning of the disease. Malignant papillomata conforming to the epithelial type of tumor occur more frequently in advanced life.

Rectal Diseases.—Race.—Here again the colored race is more fortunate than the white. In a series of cases I found that for one negro affected with any disease of the rectum, there were six whites. Hemorrhoids are said to be rare among the North American Indians; VanBuren and Winter furnishing authority for this statement. Rectal diseases are reported to be common with the Mexicans, supposed to be due to the free use of meschal. Jews also are frequently affected by diseases of the rectum. Many surgeons connected with hospitals having largely a Hebrew population write me that rectal affections are exceedingly common in this race. Gerster, of New York, for many years surgeon to Mt. Sinai Hospital, where the patients are mostly Hebrews, tells me that rectal diseases are unusually common in this race.

There is one exception to be made to the statement that negroes suffer less frequently from diseases of the rectum than the whites, namely, fistula in ano. It would seem that this occurs about as often in blacks as in whites, and most frequently of all in the mulatto. The liability of the negro to tuberculosis often finding expression in an ischiorectal abscess, explains the more frequent occurrences of fistula than other diseases of the rectum in this race. Fistula seems also to be more fatal in the colored race, there having been nearly twice as many deaths occurring in negroes as in whites in a population in which the negro is as 1 to 4.

This would indicate fistula in the negro to be about eight times as fatal as in the white.

It should also be remembered that both the full-blood and mulatto are more impressionable to pyogenic organisms and sepsis in general than the whites. This fact and their well-known indifference to all laws of hygiene and cleanliness, together with their greater liability to local tuberculosis, fully explains their heavy mortality from fistula. Ischiorectal abscess is probably more frequently than not tuberculous.

Sex.—That sex has an influence is indicated by a large number of cases collected by me, in which the ratio was 3 males to 1 female.

Age.—Although children frequently suffer from prolapsus ani and polypi, they rarely suffer from other rectal affections. Elderly persons also seem to enjoy a relative immunity, although they suffer more frequently from rectal carcinoma, which, however, is, comparatively speaking, a rare disease. The ordinary affections in this region, such as hemorrhoids, ischiorectal abscesses, fistulas, and fissures are most prone to occur during middle life. Few people suffer from hemorrhoids under the age of twenty. Although fistulas and fissures may be more frequently seen in young adults than hemorrhoids, even they are more common in middle life.

Surgical Tuberculosis.—Of all of the diseases to which the negro and North American Indian have fallen heir, tuberculosis in all of its forms has proved the most fatal. It is more than twice as frequently seen in the negro as in the white, and I may say with safety is still more prevalent in the Indian, the latter race suffering directly in proportion as they give up their tepee life and live in poorly ventilated huts. This is to be expected from a germ disease. Both negroes and Indians are notoriously unhygienic, many individuals living in one room, oftentimes where the cooking is also done and the floor is freely spat upon.

This is true not only of pulmonary tuberculosis, but also of surgical tuberculosis. I have been informed by reliable observers in the medical corps of the Army and Indian Departments that an enormous percentage of Indian boys and girls develop one or more varieties of surgical tuberculosis as they give up their outdoor life for the school-room. Mexicans have also become as susceptible to surgical tuberculosis as the Indian. I believe that surgical tuberculosis occurs in all other races.

Age.—Surgical tuberculosis is pre-eminently a disease of the very young. The first decennium will furnish the majority of cases; the second decennium about one-fourth of the total number, and the remainder will occur after twenty.

Sex has no influence.

Neoplasms.—Perhaps the greatest difference to be found between the white and black race is in their relative tendency to tumors in general. While the difference obtaining so far as special organs are concerned will be taken up later on under the proper headings, we may say in general that there are certain differences so marked and characteristic as to have been noted by medical and lay observers from the beginning of authentic history concerning the two races.

Benign Neoplasms.—*Race.*—There are many benign tumors to which

the negro is more prone than the white man. It is a well-known fact that fibromata, lipomata, and keloids are much more common in the negro and the mulatto than in the Caucasian. Molluscum fibrosum was at one time thought to be an affection peculiar to the tropical negro. This is far from true, as the affection is occasionally encountered in all parts of North America, though it is, perhaps, less common in northern latitudes and in white races. I have seen many cases in the whites and I am certain that it is more common with them than was formerly believed. The cases that I have seen in whites have been striking instances of this disease, and nearly all were in males past forty. Strangely enough, I will say that I have seen this disease more often in the white than in the black.

The tendency to keloidal formations in the black race has been remarked upon and emphasized by all who have written on the subject. In many of them the slightest scratch will be followed by an ugly scar. It is a very common thing to find negresses with tumors on the lobules of the ear, occasioned by piercing the ears and wearing ear-rings. In fact, the keloidal tendency nearly always begins in a cicatrix following surgical operations and at the point of needle punctures. I called attention to this fact twenty years ago and advised skin-grafting rather than closing the wound by sutures in cases manifesting a pronounced tendency to keloidal formations. I do not assert that it will prevent, but it certainly will lessen, the probability of recurrence in case extirpation is decided upon. It is questionable, however, if keloids should be operated on in young subjects, while in the very old operation is unnecessary, as there is a tendency for them to undergo resolution. There is, I believe, no difference in the two sexes as respects liability.

I have also seen in my practice many instances of keloids in the whites following minor operations, such as vaccination.

Sex.—There are no essential differences between the two sexes so far as concerns their liability to most benign neoplasms. The most striking one obtains in the case of myomata, which are many times more common in women on account of the vulnerability of the uterus.

Of course, it is well understood that we are not including cysts, simple or compound, congenital or acquired. It should be remembered, however, that dermoids, though of congenital origin, are stimulated by puberty, and may entirely escape notice up to that period, and, therefore, be considered of recent formation.

Age.—Age is a more important predisposing factor in the etiology of benign neoplasms than is sex. The young, especially in the first decennium, rarely suffer from benign tumors, except those of congenital origin, as lymphangiomata, meningocele, and other rare kinds of tumors originating from congenital anlage. Fibromata, osteomata, and chrondromata are rarely seen under twenty, and all, with the possible exception of chondromata, increase with each decade.

Malignant Neoplasms.—From all early records it would appear that both carcinoma and sarcoma occurred but rarely in the negro. Furthermore, this is equally true of the North American Indian. Recent statistics, however, have clearly shown that while the negro at the present

time is not as susceptible to malignant disease in general, some of his organs are as vulnerable, others more so, than is the case with the white race.

During my residence in Kentucky I saw at the Louisville City Hospital a large number of cases of malignant disease in whites and blacks of both sexes. I think it is safe to say that the negro is relatively somewhat more prone to sarcoma than to cancer. As a race they are particularly liable, however, to carcinoma of the uterus, and from my experience and the statistics furnished me by various Southern surgeons I think that they suffer relatively as often from carcinoma of the breast as the white race.

According to the United States Census, malignant disease occurs in every 100,000 living inhabitants:

Whites	53.93
Negroes	36.65
North American Indians	5.31

Chinese a little less liable than Indians.

To every 1000 deaths from known causes in the United States in persons over forty-five years of age, there were due to cancer and tumor:

Whites	62.86
Negroes	29.81
North American Indians	14.49
Chinese	12.99

Without a doubt cancer in all races and both sexes is decidedly on the increase. It has been stated that cancer is relatively less frequent in Hebrews, but I believe this statement to be erroneous. It is certainly not borne out by clinical experience in the United States. Out of 219 cases of cancer treated in the Jewish Hospital, Philadelphia, 109 were in Jews. In this hospital Jews constitute less than one-half the entire number of patients.

Cancer is rare in all savage races and is pre-eminently an affection which increases in frequency as they advance in civilization. Dark-skinned races apparently suffer less than the fair.

Cancer is rare in the Indian, and when it does occur, it usually attacks the breast and uterus. Liable as the negro is to carcinoma of the mammary gland and uterus, other organs which one would expect to be most obnoxious suffer infrequently. I might add that carcinomata of the external genitalia, larynx, and tongue are rare in the negro, while rectal cancers are common.

Sex.—Malignant disease attacks women with greater frequency than men, because of their proneness to disease of the uterus and mammary gland, which embrace one-half of the cases in this sex. That females suffer more frequently from cancer has been shown by W. Roger Williams and Snow's statistics gathered from the Cancer Hospital in London.

Age.—Carcinoma is a disease of late life, as a rule. Up to the twenty-fifth year, both sexes suffer with equal frequency from carcinoma in general. However, from the twenty-fifth to the fifty-fifth year,

woman is nearly three times as liable to malignant disease, and from fifty-five to ninety is about twice as obnoxious to it as man.

Gusserow, who analyzed 3385 cases of uterine cancer, found only two to have occurred before the twentieth year, while in Gross's series of 1622 mammary cancers, the youngest patient was twenty-one. These cases illustrate the heavy tribute woman pays to malignant disease during the activity and evolution of the sexual organs.

Infancy and childhood being practically exempt from all epithelial tumors, rarely suffer from cancer, the youngest case on record to my knowledge being one of cylindroma of the rectum in a child aged eleven.

Of 1620 deaths from malignant disease reported by the Louisville Board of Health, 1413 were in whites and 207 in colored. The normal proportion of colored population to white in Louisville at the time that these statistics were compiled was 1 to 4, so it may be shown that the mortality from cancer in general in the colored population is about 50 per cent. of what it is in the white. These statistics, though compiled ten years ago, I believe to be accurate today; moreover, they agree fully with the statistics furnished by the Charity Hospital in New Orleans, where a large amount of operating is done for malignant disease in the whites and negroes of both sexes. These statistics coincide with Billings' census report; the death-rate being 53.93 to every 100,000 living white inhabitants and 36.65 colored. All of the above statistics quoted represent post-mortem observations, and are, therefore, more accurate than data based upon clinical observations.

Special Forms of Carcinoma.—*Mammary Gland.*—Though commonly thought to be rare in the negro during the earlier periods of surgical history in the United States, mammary carcinoma is relatively as common in the black as in the white race. In a rather large operative experience for malignant disease of the mammary gland, I have found relatively no discrepancy between the races. In fact, the first case of cancer of the breast I ever saw was in a negress about forty years of age. She died from recurrence after operation, which, of course, confirmed the clinical diagnosis. I have since seen many cases of carcinoma of the breast in the negro.

There were 839 cases of cancer of the breast reported in the eleventh census—811 females, 28 males. One occurred under fifteen years of age; 163 between fifteen and forty-five; and 670 at and over forty-five. Rate of death to 100,000 inhabitants: females, 823; males, 0.29. Age forty-five to sixty-five, 30.08; sixty-five and over, 50. Death-rate practically the same in white and colored, being 4.27 in the former and 4.19 in the latter.

The early writings on the subject of mammary carcinoma prove that it was a very rare occurrence in the Indian. It occurs, according to W. Roger Williams, quite often in Chinese. He quotes Cantlie, and states that of one hundred and fourteen cases of carcinoma affecting Chinese, thirty-eight were mammary; and also that eleven out of thirty operations for malignant disease performed in one year at Kerr's hospital in Canton were for neoplasms of the breast.

Age.—Carcinoma of the breast occurs more frequently under thirty years of age than has been believed. In my recent work on the subject I have stated that 11 per cent. of all cases occur between twenty and thirty years of age; between the ages of thirty and forty, 12.5 per cent.; between the ages of forty and fifty, 27 per cent.; between the ages of fifty and sixty, 28 per cent., and 21.5 per cent. occur after sixty. So it would be safe to say that carcinoma of the breast is a disease affecting people that have, as a rule, passed middle life.

Sex.—Not more than 1 per cent. of all cases of carcinoma in this location occurs in men. Out of 1460 cases of mammary carcinoma studied by Keyser, only ten affected the male breast. Of three hundred and seven cases treated at the Johns Hopkins Hospital, Warfield states that only three were in men.

Farantino found only one case in 228 and Sick found only two in 616. These figures do not show such a high percentage among men as those of some other authors; for instance, Billroth stated the percentage to be 2.82.

Carcinoma of the Uterus.—Carcinoma in this location is undoubtedly more common in the colored race. According to the eleventh census, there were 1472 cases reported. The death-rate was 24.94 per cent. in the negro and 14.41 per cent. in the white race.

The following table shows the death-rate of 100,000 during the census period at all ages:

	All Ages.	15 to 45 Years.	45 to 65 Years.	65 Years and Over.
Total	14.93	9.32	54.01	45.91
White	14.41	8.79	52.29	44.36
Native-born	10.98	7.51	51.71	43.71
Foreign-born	22.92	11.98	50.79	41.77
Colored	24.94	18.82	94.59	88.36

Other authentic records show cancer of the uterus to be more common in the black race. Further statistics compiled by me when living in Louisville show that during a period of twenty years there were two hundred and seventy-two deaths from cancer of the uterus reported to the Board of Health. Of this number, two hundred and sixteen were white and fifty-six colored, and as at that time the normal population was in the ratio of 1 black to 4 whites, this shows a percentage against the negro.

Cancer of the Penis.—I have never seen cancer of the penis in the black race, but know of an undoubted case operated on in this city. This patient, an elderly subject, was operated on last year at the Pennsylvania Hospital. Bloodgood states that he has seen two cases. Payne and J. R. Wathen have also each had one case, the latter having sent me the removed specimen. It cannot be questioned. I know of several cases which were diagnosticated as cancer, and one of them even depicted as such in text-books, which were subsequently shown to be either syphilis or tuberculosis.

Cancer of the Stomach.—Gastric carcinoma is rarer in negroes than in whites. Osler, who has studied the subject carefully, gives its incidence as 6 whites to 1 negro.

Sex.—Men are more commonly affected than women. Of 1500 cases collected from various sources, 986 were in males and 514 in females. Post-mortem statistics from Kiel showed more than three-fourths of all cases to have been in the male sex.

Age.—Cancer of the stomach is most common between the ages of forty and sixty. Of 1600 cases which I recently had collected from various sources, 35 per cent. occurred between the ages of forty and fifty and 33 per cent. between the ages of fifty and sixty. Young persons, however, are not immune. De la Camp has reported three cases in patients aged fourteen, sixteen, and eighteen years respectively. In an analysis of 9906 cases he found that nineteen patients under nineteen years of age were affected.

Sarcoma.—I have been unable to find statistics bearing upon the frequency of sarcoma in any particular race. I believe, however, from my own clinical experience, that this form of malignant disease occurs relatively more frequently in the colored race than in the white; probably because as a class they are laboring people and more liable to injury. Coley, whose experience with sarcomata has been very large, dilates upon and emphasizes the fact that this class of tumors is apt to follow an injury. He believes that the micro-parasitic theory bears more weight than any of the many others advanced to explain the origin of sarcomata. Especially is an injury to any of the long bones apt to be followed by sarcoma, as shown by his statistics. Of a series of 630 cases observed by Coley from 1890 to date, 234 cases, or a percentage of 37, originated in bones. Of the long bones, the femur and tibia are most frequently affected.

Age.—Sarcoma affects by preference the two extremes of life, though it may occur at any age. The majority of tumors seen in childhood—during the first decennium of life—are sarcomata, since at this time benign neoplasms, as well as carcinomata, rarely occur. In fact, sarcomata are often congenital, and such instances in which the eye, kidney, testis, and prostate were thus affected have been frequently met with. Duzan analyzed one hundred and eighty-two cases of sarcoma in infancy, and found seventy of the eye, forty-five of the kidney, eleven of the testicle, eight of the prostate, while the bones, tongue, abdomen, and brain were affected five times each; the lung and dura mater, four times; pancreas, three; liver, tonsil, rectum, two each; stomach, one.

After the tenth year, sarcoma of the long bones becomes more frequent, and between the thirtieth and fortieth years some of them, such as the femur, tibia, and humerus, exhibit their greatest liability to sarcomatous change. Coley, in his latest paper on sarcoma of bones, quoted before, states that thirty-nine out of seventy-two cases of sarcoma of long bones occurred in the femur, that the ages ranged from one and one-half to fifty-eight years, that eighteen of the patients were females.

Sarcoma is rather uncommon after forty and remains so until sixty, when it again is seen to increase in frequency as a senescent change.

The following tables were compiled by W. Roger Williams and were taken from his work on "Malignant Tumors in Infancy, Childhood, and Youth":

TABLE 1.—SHOWING THE DEATHS DUE TO MALIGNANT DISEASES AT DIFFERENT AGE PERIODS:

AGE	MALES	FEMALES
Under one year	8	7
One to two years	6	6
Two to three years	6	6
Three to four years	6	6
Four to five years	5	6
Five to ten years	18	15
Ten to fifteen years	18	18
Fifteen to twenty years	33	25
Twenty to twenty-five years	50	41
Twenty-five to thirty-five years	145	321
Thirty-five to forty-five years	426	1,313
Forty-five to fifty-five years	1,095	2,464
Fifty-five to sixty-five years	1,727	2,922
Sixty-five to seventy-five years	1,555	2,330
Seventy-five to eighty-five years	591	910
Over eighty-five years	65	101
All ages	5,754	10,491

Total under five years: Males, 31; females, 31.
Total both sexes, 16,243.

TABLE 2.—SHOWING THE NUMBER OF DEATHS FROM MALIGNANT DISEASE IN EARLY LIFE PER MILLION AT EACH AGE PERIOD:

	1861–70	1871–80	1881–90
Under five years	13	12	20
Five to ten years	7	7	10
Ten to fifteen years	7	7	11
Fifteen to twenty-years	7	15	20
Twenty to twenty-five years	17	27	35
All ages	384	464	539

Sex.—During early life, sarcomata are seen with equal frequency in both sexes. After the tenth year there is a slight preponderance against the male sex, probably due to their greater liability to injury.

Tetanus.—Race.—I saw many cases of tetanus in the newborn while practising in the south, since it is often met with in the negroes there. The disease is more common among the dark-skinned races the world over, as the military records of Spain, France, Italy, and Japan bear witness. The nearer the tropics, the greater its frequency. The explanation probably lies in the fact that while the bacillus of Nicolaer will live in temperate and even cold climates, it flourishes the better as the tropics are reached. The Jews, both here and in Russia, are said to frequently contract tetanus. It would seem that a ready explanation lies in the fact that circumcision is universally practised as a religious rite by the Jewish priests or mohels who know nothing of asepsis.

Sex.—Tetanus is more frequently seen in males than in females, not because of any predisposition thereto, but simply for the reason that they are more exposed to injury. For instance, it is well known that boys

frequently suffer from tetanus caused by toy pistols and other firearms. They are more frequently the victims of all kinds of accidents than girls.

Age.—This disease may occur at any age, requiring only the presence of the bacillus of Nicolaer and a wound for its development. The majority of cases are met with in children, ranging in age from the newborn to young adult life. Trismus neonatorum, perhaps, is the most common manifestation of this disease encountered, and in tropical climates, where uncleanliness is the rule in dealing with the stump of the umbilical cord, the infant mortality is frightful. Such, for example, is the case among the Sandwich Islanders. It is also quite frequent in Jamaica. Authorities have stated that the infant mortality with these people is at times as high as 50 per cent., the result of trismus neonatorum alone.

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